SEVENTH FRAMEWORK PROGRAMME

Proposal full title:

Development of a wireless non-invasive skeletal muscle diagnostics technology in voluntary conditions and its applications

Proposal acronym:

DiaMus

Type of funding scheme:

STREP

Work programme topics addressed:

ICT 2009.3.9 (c.1.iii) Microsystems and smart miniaturized systems

Name of the coordinating person:

Dr. Bostjan Simunic

List of participants:

Participant number	Participant organization name	Participant short name	Country
1(Coordinator)	TMG, Ljubljana, http://www.tensiomyography.com/	TMG	Slovenia
2	Faculty of Electrical Engineering, University of Belgrade, Serbia http://www.etf.bg.ac.rs/	BGDUNI	Serbia
3	Consorzio Ferrara Ricerche http://www.consorzioferrararicerche.it	FERRARA	Italy
4	MEDIApro, Barcelona, Spain : http://www.mediapro.es	MEDIA	Spain
5	Institute of Orthopedic Surgery and Traumatology, Belgrade, Serbia http://www.med.bg.ac.yu	ORTO	Serbia
6	University of Primorska, Slovenia http://www.zrs.upr.si/	KOPUNI	Slovenia
7	Our Space d.o.o. http://www.ourspace.si	SPACE	Slovenia
8	University of Ljubljana, Faculty of Electrical Engineering http://www.fe.uni-lj.si	FE	Slovenia

9	University of Ljubljana, Faculty of Computer and Information Science http://www.fri.uni-lj.si/	FRI	Slovenia
10	Barcelona Supercomputing Centre, Barcelona, Spain http://www.bsc.es/	BSC	Spain

Proposal abstract

One important class of microsystems interacting with human body is dedicated to monitoring and diagnostics. This technology has a tremendous impact, both in the medical and economical domains; according to official EU sources, only in 2008, more than 220 billion EUR was used for diagnostics and treatment of musculoskeletal disorders. The major problems of this technology are: how to make it miniature, wireless, with a zero impact of equipment on muscle/body response, non-invasive, usable while the patient/subject is doing voluntary movements, and with sensors for a large variety of applications, producing a holistic picture (rather than producing an isolated set of parameters). Additional challenge is how to enhance it with intelligent software, which enables data-mining, concept modelling, and is compatible with the principles of semantic web. Existing technology is mostly wired and static (voluntary movements not possible), with a single sensor (and a limited number of applications), generating the information based on a limited set of isolated parameters, and only with simple analytical capabilities (no software assistants). The objective of the proposed project DiaMus is to generate a next generation technology for musculoskeletal disorders diagnostics, with major departures in all the dimensions listed above, during the voluntary movement, completely wireless and non invasive, using a variety of sensors for: muscle tension measurements (the original MC-MEMS to be introduced by this project), 3D acceleration, 3D gyro, EMG, and potentially many others, as well as a sophisticated analysis software based on data-mining, concept modelling, and semantic web. This can expand the application domain to about 20 different use cases (in medical diagnostics, rehabilitation, wellness, sports, etc...). All the newly introduced applications will be tested on a statistically significant number of subjects, in the leading hospitals of two different countries/populations.

Table of contents:

Proposal

1. Scientific and/or technical quality, relevant to the topics addressed by the call

1.1 . Concept and objectives

The major concept behind this proposal is to connect synergistically the following fields: (MDS) medical diagnostic systems, RMS (rehabilitation medicine systems), SMS (sports medicine systems), ECE (electrical and computer engineering), WSN (wireless sensor networks), INT (Internet technology), SEM (software engineering methodology), DMS (data mining systems), SWS (semantic web systems) and CAI (conceptual artificial intelligence); all that for the success of the next generation non-invasive voluntary diagnostics technology. Also, new sensor technology (the newly developed sensor MC-MEMS) is one of the major contributions of this project.

This major strategy is fully compatible with major goals expressed in Call 5, Challenge ICT-2009.3.9(c.1.iii).

To stress the compatibility and competitiveness of our approach, we paraphrase here the essential points of Call 5, Challenge ICT-2009.3.9 (c, 1, iii): Microsystems interacting with human body, with particular emphasis on autonomous, and non-invasive (approaches), for monitoring, diagnosis, and therapy.

Our approach in this proposal is a continuation (follow-up) of other existing or past EU projects (FP7) in which members of this consortium participated or are currently participating: ProSense (wireless sensor networks), SenSei (Internet of things). Essentially, while working on previous projects, ideas were generated which, although excellent, were not doable within the scope of those projects, because they were out of the scope of those projects.

What follows is the description of the basic concept behind the proposed approach, in comparison with the existing state-of-the-art.

Existing solution:

The existing state-of-the-art (e.g., the existing TMG system) is used worldwide (list of references is given in Figure 4 of this proposal), and includes the following functionalities:

a. TMG (Tensiomyography) method, which is classified as a mechanomyographical (MMG) method based on detection of muscle belly enlargement in the radial direction, when the muscle contraction is elicited by single twitch electrical stimuli.

b. Analysis of the response (muscle twitch contraction) and extraction of the parameters from the response, like:

Maximal amplitude of the signal/contraction (Dm)

Delay time - from the stimulation to 10% of the maximal contraction (td),

Contraction time - from 10% to 90% of the maximal contraction (tc)

Sustain time - from 50% contraction to 50% of the relaxation (ts)

Relaxation time - from 10% relaxation to 50% relaxation (tr).

Amplitude vector (list of maxima, if more than one), etc...

c. Based on these parameters and previous studies (see the references), the basic muscle contractile properties can be defined. Differences from the reference values for the parameters can indicate physiological (fatigue, potentiation...), pathophysiological (myopathy, neuropathy...) and aging related changes (sarcopenia…), and can be applied in various domains (medical sciences, applied physiology, sport sciences…).

d. State-of-the-art is using a wired technology.

e. State-of-the-art is using only one type of sensor, and doing only the basic skeletal muscle diagnostics.

f. State-of-the-art is not data mining the response results.

g. State-of-the-art is covering a limited number of potential use cases.

h. State-of-the-art can serve as an excellent baseline for advanced research leading to a next-generation technology, which overpasses all drawbacks listed above.

The goal of this project is to do research leading to creation of an innovative system whose functionalities and use cases are explained next:

Functionalities (to support expanded applications and use cases):

a. Existing hardware is redesigned, to include faster components, WSN, and till-now-non-existing processing capabilities, as indicated in Appendix 2. Special attention is given to the following issues:

Hardware which gets reconfigured according to user needs

Human interface which can get reconfigured according to user needs

b. Existing hardware is expanded with a larger number of modern sensors, so the consortium can experiment with novel domains, and their usage in diagnostics/treatment and optimization applications.

c. A specialized piece of system software is added.

d. The specialized piece of software mentioned above is organized around a software agent capable of collecting data from the measurements and from the environment in real conditions (not just laboratory).

e. The system guarantees privacy in the sense that information collected by the software agent will not be publicized or abused in any sense. The privacy guarantees should be placed at the highest trust level.

f. Software agent monitors the processes in the system. In that activity it uses the data from:

The stimulus - contraction relation (e.g., information from built-in sensors)

The sensor network system (e.g., information from sensors of the environment)

The Internet system (e.g., public knowledge)

The direct inquiry, which is done only if absolutely necessary (e.g., asking direct questions from the patient, like anamnesis).

g. The collected data are pre-processed on the spot, and passed to a central data mine, inside the system, which is connected to the Internet, for the benefit of the community, if so needed.

h. At the central data mine system (DMS), using the algorithms of concepts oriented artificial intelligence (CAI), the concepts related to possible diagnostics options are extracted, and used to generate recommendations. This is an extremely sophisticated task, to connect movements, loads, electrophysiological changes and muscle contraction forms, as well as the synergistic interactions there-off. Appendix 3 gives an example of concept modelling used in this environment.

i. The extracted information is related to built-in sensors, but also to external environment. A selected subset of that information, only the subset which is of general nature, and not abusing the privacy of any customer, is made available via the Internet.

j. The system can monitor a large number of DSPs (diagnostics optimization parameters) and EAPs (environment awareness parameters). These can be processed using a number of KEPs (knowledge extraction procedures), and refined using a number of CEAs (concept extraction

algorithms). Once the concepts are extracted, concrete recommendations (in a ranking order) are generated using appropriate RRGs (ranked recommendation generators).

k. A list of current beneficiaries of the state-of-the-art TMG system is given in Figure 4. The above described system architecture is depicted in Figure 1.

Examples of Use Cases for the Technology to be developed by This Project:

The cases to follow are enlisted in the order of the level of elaboration, and the level of elaboration corresponds to the level of importance for the main focus of this proposal (most of them are related to orthopedics). The less elaborated examples will be the subject of screening and analysis during the course of the project.

a. Optimization of the rehabilitation process. Young patients, who are active and who had anterior cruciate ligament injury (ligamentum cruciatum anterius) and underwent reconstructive surgery, will be taken into consideration for the assessments. The deficiency of quadriceps and hamstrings will be assessed after surgical procedure. Comparing the muscle (vastus lateralis, rectus femoris, vastus medialis, biceps femoris, semi–tedinosus/membranosus, lateral and medial part of gastrocnemius) properties on both sides (injured and healthy) before and after surgery, during recovery period, we can optimize rehabilitation processes. Monitoring functional and morphological changes (muscle activation pattern, muscle fatigue, amplitude of contraction-relative force…) on each particular muscle can make a rehabilitation process more efficient and shorter. The aim of assessment would be to prevent re-injury, to reduce the cost of in-patient treatment, and to help patients resume their sport and “active life” activities when a balance of muscle strength ratio and neuromuscular properties between operated and non-operated has been attained.

b. Mononeuropathies related diagnostics. Mononeuropathies can occur secondary to direct trauma, compression, stretch injury, ischemia, infection, or inflammatory disease. The knowledge about peroneal nerve anatomy is essential to understand the mechanism of its injury and to localize the site of the lesion. The patients with peroneal mononeuropathy experience frequent tripping due to a foot drop. EMG is useful to localize the lesion. It can be helpful in determining which nerve is involved primarily—the **common peroneal nerve** at the knee or one of its two branches, the superficial or **deep peroneal nerve**. The **tibialis anterior** or extensor hallicus longus muscles (i.e., innervated by the deep peroneal) and the **peroneus longus** or brevis muscles (i.e., innervated by the superficial peroneal) are useful to study for this purpose. EMG is also helpful in determining if the foot drop is due to an L5 radiculopathy or a sciatic lesion. In an L5 radiculopathy, the tibialis posterior, which is a foot inverter, and the **lumbosacral** paraspinous muscles are involved.

c. Post-reconstructive ACL surgery monitoring. Young active patients, who had **anterior cruciate ligament** injury (ligamentum cruciatum anterius) and underwent reconstructive surgery, will be taken into consideration for the assessments. The deficiency of quadriceps and hamstrings will be assessed after surgical procedures. Comparing the muscle (vastus lateralis, rectus femoris, vastus medialis, biceps femoris, semi–tedinosus/membranosus,

lateral and medial part of gastrocnemius) properties on both sides (injured and healthy) before and after surgery, during recovery period, we can optimize rehabilitation processes. Monitoring functional and morphological changes (muscle activation pattern, muscle fatigue, amplitude of contraction-relative force…) on each particular muscle can make a rehabilitation process more efficient and shorter.. The aim of assessment would be to prevent re-injury, to reduce the cost of in-patient treatment, and to help patients resume their sport and "active life" when a balance of muscle strength ratio and neuromuscular properties between operated and non-operated has been attained.

d. Re-injury prevention. Involvement of the peroneal division of the sciatic nerve in the thigh or hip area is more difficult to determine clinically**. In the thigh, the peroneal division of the sciatic nerve innervates the short head of the biceps femoris muscle, a knee flexor. EMG may be necessary to determine involvement. With this new wireless technology we could evaluate functional and morphological condition on particular muscle before injury, during (after) treatment and during recovery period. The aim of assessment would be to prevent re-injury, to reduce the cost of treatment and rehabilitation.**

e. Talent selection. Use of Diamus as a screening method for young athletes participating in various sports and thereby identifying exceptional talents for a specific sport/event (speed dominant, force dominant, anaerobic, mixing and aerobic type if exercises /performance). For each type of the load different test procedures will be developed based on 10 years of TMG technology sport application, these will include a basic test for distribution of fast twitch muscle fibers and evaluation of muscles balance important for the particular sport. Based on previous study, talent screening will be done with 9-12 years-old children. . Classification will be based on muscle biomechanical and physiological properties detectable with DiaMus sensors (during running, jumping...).

f. Clinical rehabilitation optimization. Optimization of rehabilitation processes and prediction of rehabilitation process duration which takes into consideration an expanded set of measured/sensed parameters. This is of interest for the patients who are not covered by insurance and pay for rehabilitation (to know when to stop and when is probability of re-injuries reasonably low), as well as for insurance companies in cases when they cover the rehabilitation costs (in order to minimize expenses). This use case also includes the recommendations for clinical rehabilitation end point conditions/standards, in the cases when synergistic effects of various measured parameters are present.

g. Maximizing sport results without application of doping. Development of more efficient training protocols for development of speed of running and movement, using the DiaMus sensor system. Emphasis will be put on muscle fatigue, activation pattern strategy, potentiation of muscle twitch contraction, flexibility-muscle force relation and biomechanical efficiency. by monitoring and evaluating these the training protocols can be accordingly adjusted. Majority of protocols (3-5) will be done in real movement conditions. This approach can help young sportsmen and coaches to develop result, based on better understanding and monitoring of stimulus (training) adaptation relation.

h. Complex muscle asymmetry detection for both ill/injured and healthy (based on an expanded set of sensors). It has been proven that muscle asymmetry increases the probability of injuries/re-injuries (both for ill/injured and healthy subjects, including sedentary, active population and sportsmen), and it is important to expand the number of measured (sensed) parameters that can point to muscle asymmetries: functional and morphological. This use case also includes generation of recommendations for treatment of all realistically possible types of muscle asymmetries which exceed recommended standards.

i. Real time detection and monitoring of psycho physiological abilities (neuromuscular component) of police special armed force officers or soldiers. **This use case also includes a study or real time monitoring the effect of different types of fatigue/excitation on working capability measured in extreme real condition (exercise, simulations and real combat). Psychomotor agitation makes the reactions faster, but less controlled, reaction patterns change, if the person is in local or central fatigue condition. Monitoring with the multisensor-noninvasive approach can obtain data necessary for making better decisions in training process and in real conditions.**

j. Movement pattern optimization, for sports. The equipment can generate conditions for small pain, if the skeletal muscle movement is outside the scope of the pre-programmed trajectory. Movement primitives can be defined, as well as the criteria for successful movements. Departures from optimal can be classified as still correct or not correct. Criteria of successful achievement of the end goal can be set (the end goal may be a better score against an opponent, or another higher-level goal). Specification of RTP (recommended treatment procedures).

k. Post-surgery muscle damage detection and monitoring. Measurements will be performed on patients with hip fracture or hip osteoarthritis who underwent hemiarthroplasty or total hip replacement. We would record properties of m.gluteus maximus before and after surgery. Gluteus maximus is the powerful extensor of the hip, especially when the knee is flexed. The damage of gluteus maximus results in weakened extension. The aim of the measurements would be to detect muscle damage during posterior surgical approach. Based on the results, we could improve surgical approach (with minimal muscle damage), which would help us optimize postoperative period.

l. Post-surgery shoulder rehabilitation optimization. At anterior dislocation of the shoulder (by far the most common pattern) one of the serious complications is a damage to the auxiliary nerve as it runs around the neck of the humerus. This damage causes partial or complete paralysis of the deltoid, which results in weakened abduction of the arm and muscle atrophy. According to standard procedures, when damage is suspected, the auxiliary nerve should be examined with an EMG 3[Computer2] weeks after injury and 3 weeks afterwards, which is very painful for a patient. With this wireless technology, we could recognize this condition effectively and it would be painless for the patient. We could also evaluate and optimize rehabilitation period (by comparing injured shoulder to the healthy shoulder).

m. Recovery process optimization of distal radius fractures. The distal radius fracture is one of the most common injures of the upper limbs. The largest numbers of these injuries are treated non-operatively (orthopedic reduction and cast immobilization for 4-6 weeks). The complications are frequent after this serious injury. The median nerve runs right across the site of a Colles´s fracture and may be compressed by the bruising and bleeding around it. Median nerve damage in this region results in weakened thenar and thumb muscle, as well as sensitive disorders of the hand. EMG must be performed in accordance to standard procedure, which is unconformable for a patient. The aim of measurements with this new technology is detecting the damage and evaluating the recovery process.

n. Detection of negative, neutral, or positive effects of new drugs, currently under test by the drugs administration procedures. **Changes on neuromuscular system can be detected in different controlled conditions .This use case also includes screening of new active substances (potentially new commercial drugs) for dose-effect influence on the human locomotor system.**

o. Diagnostics of post-operative condition and reduced functionality of the locomotor system (e.g., following aesthetic and corrective surgery…). **The changes are a consequence of temporary partial or total immobilization. Intensity of biomechanical and physiological changes will be studied on different case sensitive muscle groups. Study of RTP (recommended treatment procedures) and total recovery is also included into this use case.**

p. Low back pain management. Low back pain is among the most frequent conditions in our clinical practice. High percentage of asymmetry, in average population, origins from their working place conditions or from improper body posture. Most of the examples of **lower back pain** origins from erector spinae lateral asymmetry which can influence muscles and joints of **lower extremities**. From our experiences we can affirm that most of the examples of **lower back pain** origins from erector spinae lateral asymmetry. Pathologic changes in muscles usually demonstrate in higher muscle tonus, which causes change in activation level of one or both sides of erector spinae. The results will help us to calculate the professional risk of low back pain developing by some occupations and to develop more efficient diagnostic for low back injure level index.

q. Evaluation of the integration level of implants and orthotics and the efficiency of their support or correction of musculoskeletal deformities and/or abnormalities of the human body. **Monitoring the influence on local muscle tissue influenced by implants and orthosisand optimisation of ergonomics and study of RTP**

Also, a number of screening studies will be performed:

r. Insight into the possible impacts of environment pollution on muscle state and potentials. **Study of RTP.**

s. Diagnostics of neuropathy and miopathy changes, which are not after the autoimmune causes study of RTP.

t. Diagnostics of some autoimmune deceases like MS, AS, or MG, which influence the skeletal muscles properties, in the early stages of disease development. **Study of RTP.**

u. Monitoring of changes on skeletal muscle properties, with aging, in the sarcopenia and functional atrophy conditions. Also, influence of different exercise programs on aging related changes. **Study of RTP.**

v. Detection of spastic disorders of muscles (level of stiffness and tightness), after brain and nerve injuries. **Study of RTP.**

x. The impact of addictives will be studied.

y. The impact of dietetic/nutrition strategies on muscle development (functional) will be studied.

z. The impact of stress condition on neuromuscular system will be studied.

This is a partial list of possible use cases. Creation of an expanded list of possible use cases will be conducted during the initial phases of the project. One use case is elaborated in Appendix 1.

Rationales:

a. To develop an existing technology into the commodity domain, which means that it has to become inexpensive to purchase, easy to use, efficient to use, and more effective.

b. To test the developed technology using a statistically large patient base.

c. To make iterative improvements based on the testing results.

d. To create ideas for the next generation of the same technology, with more applications, and more insight into the capabilities.

Goals:

During the first year, the goals are:

a. To expand the coverage of existing applications (testing with existing TMG equipment), such as: (a) Monitoring the rehab process and determining the end-of-rehab condition, by making decisions based on more than one parameter, (b) Detecting muscle asymmetries (as a cause of sport injuries) and verifying that the symmetry condition is reached, etc....

b. To create new applications, through a creative interaction among team members and interested parties externally.

c. To develop the detailed project requirements, which converts the current generation product into one which: (1) Uses the wireless technology and wireless sensor networks (WSN), (2) Uses faster software characterized by environment awareness, (3) Uses the Internet-related resources if and where necessary, and (4) Utilizes the resources of the Internet of Things (see, SENSEI)

d. Development of field test requirements, to be done at a statistically large test base.

During the second year, the goals are:

a. Development of the wireless environment: (1) Wireless data transfer, (2) Incorporation of WSN, (3) Synergization of WSN components, and (4) Bringing intelligence to the WSN synergy.

b. Development of faster software: (1) On the Micro Engine Level, (2) On the Operating System Level, (3) On the Compiler Level, and (4) On the Application level-

c. Merging with the Internet: (1) For remote display of results of on-site physician (using the principles of Semantic Web), (2) For remote diagnostics (by a remote physician), (3) For remote robotic activation, and (4) For remote robotic interaction.

d. Merging with the Internet of things

e. Doing clinical experiments that are doable at this stage.

During the third year, the goals are:

a. Testing the existing application (medical diagnostics, rehabilitation, applied physiology…) on a large statistical test base, using the newly developed equipment.

b. Testing the newly developed applications (medical diagnostics, rehabilitation, kinesiology, ergonomics study, movement optimization…).

c. Feedback-improved existing applications, retested.

d. Feedback-improved new applications, retested.

e. Analysis and comparison of results.

What follows is the description of the basic concept behind the proposed approach, in conditions when the major motivation forces are:

a. To obtain holistic information, from sensors, from the SGM, and the Internet, related to acquisition of products (PD), services (SV), human resources (HR), novel ideas (NI), as well as the information on external state of environment (EE), and about the optimal actions to take (OA). All 6 issues above are referred to as acquisition-ware (AW).

b. To obtain information which is not biased, i.e., not produced by humans involved in data acquisition, but by the technology used to monitor the activities.

c. To obtain information which is timely, i.e., self-generated continuously while processes are in progress, and not generated at discrete points chosen arbitrarily (knowing the values of field parameters, all the time).

d. Timely recognition of scenario that need attention, and system-generated suggestions for actions.

Motivation forces for the users of this type of products are:

a. Trust generation among potential users, since the impact of biased decision making is eliminated or minimized.

b. Lower costs

c. The system guarantees privacy in the sense that information collected by the software agent will not be publicized or abused in any sense. The privacy guarantees should be placed at the highest trust level. Of course, there are always some participants in related business, which do not trust even the highest trust level standards, but they are often-times willing to make trade-offs, when they see large enough benefits.

Software agent monitors the processes in the system:

a. At the central data mine system (DMS), using the algorithms of concepts oriented artificial intelligence (CAI), the concepts related to business goals are extracted, and used to generate recommendations to decision makers.

b. The extracted information is related to system optimization, but also to external environment. A selected subset of that information, only the subset which is of general nature, and not abusing the privacy of any participant in the system, is made available via the Internet.

c. If the processing delay is not short enough, the DMS needs to be expanded with appropriate HWA (hardware accelerators).

d. The system can monitor a large number of CSPs (business optimization parameters) and EAPs (environment awareness parameters). These can be processed using a number of KEPs (knowledge extraction procedures), and refined using a number of CEAs (concept extraction algorithms). Once the concepts are extracted, concrete recommendations (in a ranking order) are generated using appropriate RRGs (ranked recommendation generators).

In the above described system architecture, on the top are the patients (some of the use cases were described before); more will be introduced, elaborated, and implemented during the project run. The activities of the system are optimized using data from the Internet, data bases, sensors, mobile services, etc. Some of these data are semantically enhanced using the concepts oriented artificial intelligence (the central box), with elements of semantic web, data mining, concept modelling, and decision making. The basic idea of the system is given in Figure 1.

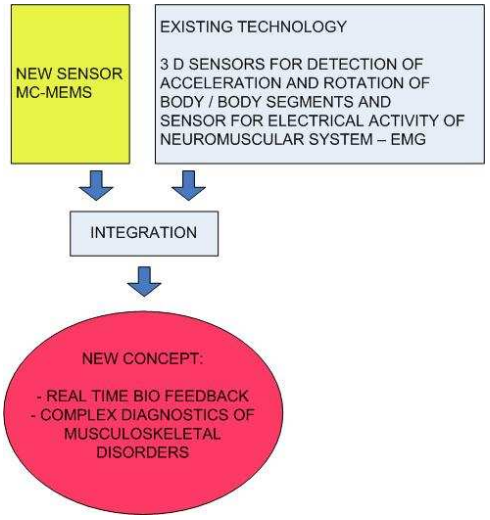


Figure 1: The basic system idea

Activities are performed by well defined procedures, using input data formatted in a standardized way, enhanced by monitors. Special attention is dedicated to the treatment of exceptions in processes. The information collection is indicated in Figure 2, together with the information processing flow in Figure 3.

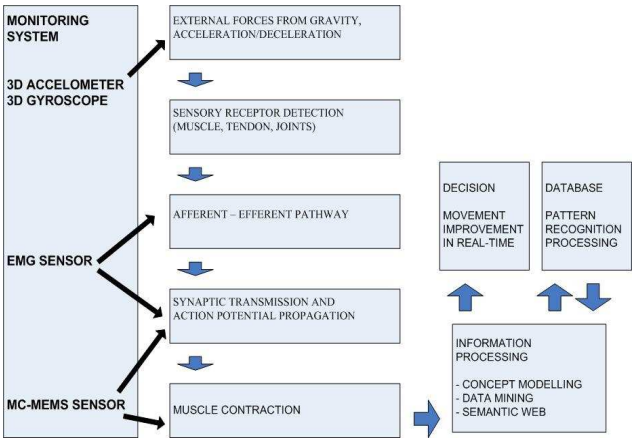


Figure 2: Information collection

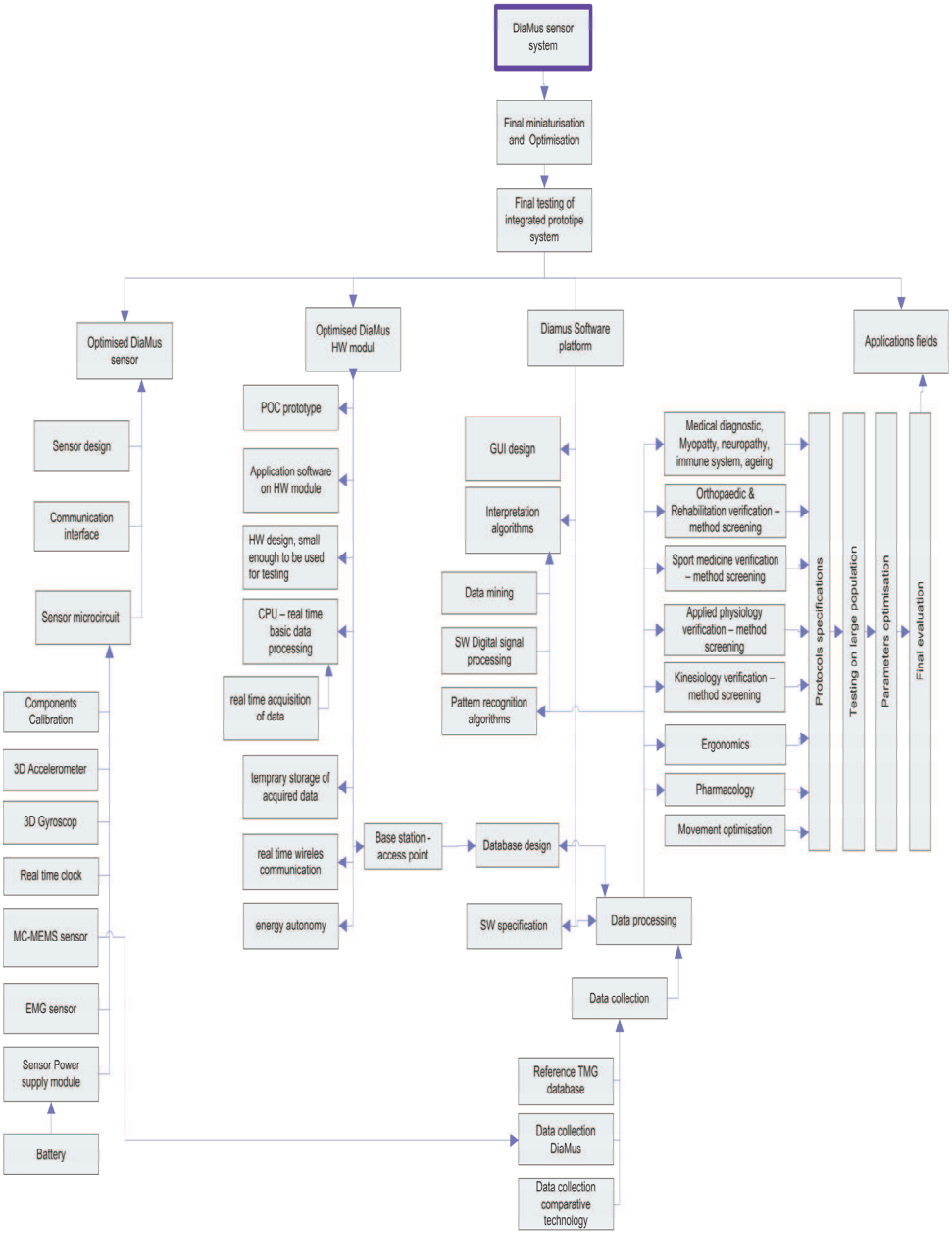


Figure 3: The information process flow

A list of past and current users of existing technology is given in Figure 4. The set of use cases will be enlarged during the first year of the project, elaborated during the second year, and a subset will be implemented during the third year of the project. A typical time domain of the response is elaborated in Figure 5.

Figure 4: List of past and current users

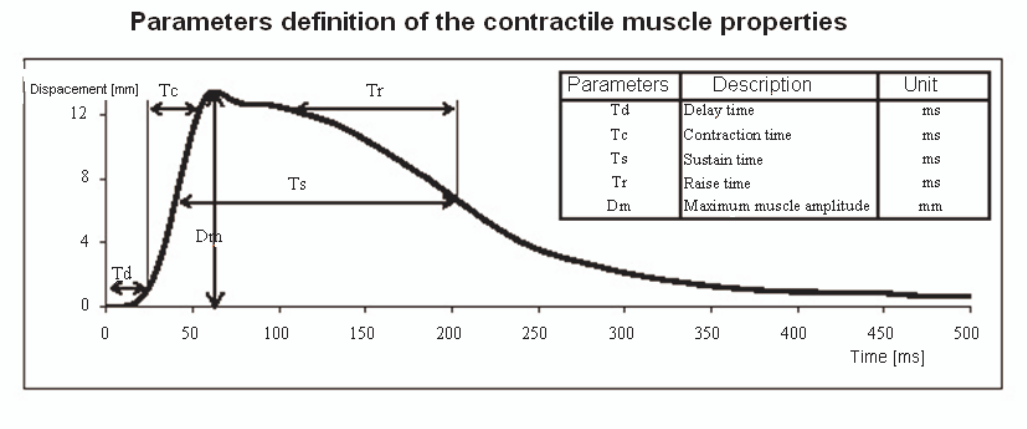


Figure 5: Typical time domain response

Important assumptions about the statistical analysis to be performed:

Most t test statistics have the form T = Z/s, where Z and s are functions of the data. Typically, Z is designed to be sensitive to the alternative hypothesis (i.e. its magnitude tends to be larger when the alternative hypothesis is true), whereas s is a scaling parameter that allows the distribution of T to be determined. The assumptions underlying a t test are that: (a) Z follows a standard normal distribution under the null hypothesis, (b) ps^2 follows a X^2 distribution with p degrees of freedom under the null hypothesis, where p is a positive constant, and (c) Z and s are independent.

In a specific type of t test, these conditions are consequences of the population being studied, and of the way in which the data are sampled. In the case of the simultaneous observation and analysis of more than one statistical variable next multivariate statistical methods will be applied (Multivariate Analysis):

- Clustering systems assign objects into groups (called clusters) so that objects from the same cluster are more similar to each other than objects from different clusters. Hotelling's T-square is a generalization of Student's t statistic that is used in multivariate hypothesis testing.

- Multivariate analysis of variance (MANOVA) methods extend analysis of variance methods to cover cases where there is more than one dependent variable and where the dependent variables cannot simply be combined.

- Regression analysis attempts to determine a linear formula that can describe how some variables respond to changes in others.

- Principal components analysis attempts to determine a smaller set of synthetic variables that could explain the original set.

- Artificial neural networks extend regression methods to non-linear multivariate models.

The data used to carry out the test should be sampled independently from the two populations being compared. This is in general not testable from the data, but if the data are known to be dependently sampled (i.e. if they were sampled in clusters), then the classical t tests discussed here may give misleading results. Major highlight of this project is synergy related to monitoring, diagnostics, and therapy, with special emphasis on environmental and technological issues.

The following are the main project objectives:

Objective 0: Project management

The goal of this objective is to make sure that absolutely each and every detail of this proposal, if it is awarded, be properly taken care of, which means: (a) All deliverables delivered in time, (b) All deliverables delivered at quality levels that satisfy the highest FP7 standards, (c) All deliverables delivered in a form which is consistent and helps convey the essence in a way which is easy to comprehend. For all this to happen, an effective set of system of reminders will be set.

Success criteria:

- Optimization of the reporting processes involved in the project (deadlines)
- Optimization of the control processes involved in the project
- Optimizing finances of the project

Objective 1: To generate use cases, which includes the following: a variety of applications, details of functionalities within each application, and definition of parameters of importance (DSPs and EAPs).

Use cases will be generated through a series of brainstorming meetings, with the purpose of taking into account a variety of applications of interest for the medical analysis, and diagnostics (this includes both, the generation of new ideas and improvements of the existing ones). An active two-way exchange of results between DiaMus partners and the EU researchers will be done through seminars and workshops. Crucial in this phase of the work is active exchange of information among DiaMus consortium members and the medico-technology firms, system developers, and concept designers at the universities. The extent of use cases should cover main functionalities of each application and definition of specific parameters of importance. Commercial challenges and their solutions will be placed and notified in the selected use cases. The opposing forces will be predesigned in each use case. Special care will be given to system constraint design and QoL, QoS and environmental impact of each use case. Six different application use cases will be documented.

Success criteria:

- Opinion of beneficiaries on the need for the generated applications, based on their knowledge about where the major unknowns are
- Opinion of beneficiaries about the functionalities provided
- Opinion of beneficiaries about optimal values of parameters involved.

Objective 2: To develop the system architecture, to determine the functionalities of all building blocks, and to develop hardware (HW), communications, and software (SW) requirements.

All details related to hardware, software, and communications have to be developed. Software details include issues like data mining, semantic web, and concept modelling. Details imply algorithm, procedures, and the operating system. The suggested DiaMus HW module will acquire various physical quantities using remote sensors. The interpretation of acquired data is a demanding task, which requires a skilled expert.

The main objective is to develop a system (software platform) for automatic signal processing, pattern recognition and final interpretation of processed data. SW platform is determined by the data acquisition process, mode of communication with HW module and methods used for signal processing and data interpretation. On that basis a suitable data model, GUI, report contents and views will be specified.

All measurements will be performed in controlled laboratory conditions that will enable the construction of the knowledge database.

Success criteria:

- Potential speed of processing and communications,
- Software and hardware architecture which permits easy expandability
- Compatibility with existing platforms

Objective 3: Adding intelligence to the system (for all six types of AW, for a relatively large number of application scenario, to define CSP and EAP parameters, and to develop related KEP procedures, appropriate CEA algorithms, and business-oriented RRG generators)

For all use cases mentioned, specific algorithms, procedures, and operating system routines will be defined, to incorporate elements of artificial intelligence (AI), using the concept modelling (CM) approach (coauthored by the members of this consortium, A Survey of Concept Modelling, submitted to IEEE Computer, 2009, and given in Appendix 4). For all of them, optimal values of related parameters will be determined and built into the algorithms,

procedures, and the operating system. Developed software module will perform automatic data interpretation based on signal processing and pattern recognition algorithms.

Success criteria:

- The number of CSP and EAP parameters defined, for a holistic coverage of major issues,
- The number of application scenario for which the KEP, CEA, and RRG are developed,
- Compatibility of the developed KEP, CEA, and RRG with the underlying architecture.

Objective 4: To design detailed hardware, communications, and software schematics, to encompass all the introduced CSPs and EAPs, all KEPs, CEAs, and RRGs, for a general future product, (which is not within the scope of this project).

For all system elements defined above, precise UML schematics will be developed. For all project activities, in the widest sense, CMMI structures will be developed. The UML schematics will be compatible with CMMI structures, and will be considered a subset there-of. This objective will gather design and implementation of a POC prototype of portable DiaMus HW module. Basic requirements for this module are:

- real time acquisition of data from different sensors (wired or wireless),
- real time basic data processing (data sampling, decimation, filtering, …),
- temporary storage of acquired data,
- real time wireless communication with portable computer or other base unit (access point),
- small enough dimensions and weight of the prototype to be used for testing
- energy autonomy for testing in real environment.

Success criteria:

- For hardware, minimal transistor count
- For communications, maximal flexibility, and
- For software, error-free structure easy to expand with plug-in software.

Objective 5: To realize a simplified PoC (proof of concept) demo, with a reduced set of functionalities, but large enough for experimenting in selected business scenario.

The starting point for this activity is the definition of the full blown system. The subset for implementation will be selected in cooperation with partner SMEs active in related fields.

This will enable local industry, in particular SMEs, to gain a more competitive position on the world market and consequently boost the local economy.

Success criteria:

- Smart reduction of functionalities so that all planned experiments can be successfully performed and the PoC prototype implemented in time and without bugs,
- Timely implementation
- Implementation without bugs

Objective 6: To test the demo system in a number of specific business scenario, in various countries, to compare experiences, to summarize the lessons learned, and to make recommendations for a market oriented prototype, which is not the subject of this proposal (it is supposed to be the subject of a follow-up spin-off activity).

Demo system developed in WP5 will be tested in real-production situations in at least two large hospitals, one in Slovenia and one in Serbia. Business scenario for the test will be selected and developed so that the experience learned from the test can be gained, compared, and further tests accomplished in order to refine the results. Thus, recommendations for the market oriented prototype can be obtained and scrutinized in the requirement specifications for the market oriented prototype. This will enable SMS's from the local, regional, or EU origin, to initiate spin-off activities both in the region where the testing was performed, and in the EU, in general. As the result of these activities, related industry, in particular SMEs, will gain a more competitive position on the world market and consequently boost the economy.

Success criteria:

- Test cases developed according to the needs of the beneficiary industry
- Specification of issues to compare which takes country specifics into consideration
- Detailness of the requirements for industrial prototype to follow.

Objective 7: To do constantly a public dissemination about this project (using media like newspapers, TV, Internet, and public lecturing), to do periodically internal workshops (for consortium members and their students) and scientific symposia (to bring together researchers from outside of this consortium), to help generate spin-off companies interested in making the market product related to this system, and to prepare the market for acquisition of this system.

The special sessions, seminars and summers schools will be open events to achieve the maximum dissemination impact and spread knowledge to cognate industries and institutions for maximal regional benefit. Suitable media events will be used to further spread information about the benefits of applications. This will enable local industry, in particular SMEs, to gain a more competitive position on the world market and consequently boost the local economy.

Success criteria:

- Number of papers presented at internal workshops and the number of papers with potentials to get accepted for publication in SCI journals

- Number of participants at workshops, one a year, for three years (min 20 participants per workshop)
- Number of participants at scientific symposia, one a year, for three years (minimal 40 per symposium)
- Number of public presentations in media (one per months, for three years), with potential partners and representatives of future spin-off companies

Objective 8: Impact on the environment. Although not typical, this project likes to have different work packages to organize and monitor effects of technical and scientific meetings, on one hand, and public dissemination with search for investors, on the other hand

Organization and monitoring of special sessions, seminars and workshops, as well as conferences will be performed in this work package. The impact of knowledge dissemination and relations to appropriate EU industries will be enforced. DiaMus project results and information gained will be further spread, both in local industry (where the testing is performed) and in EU-wide industrial organizations. A specific workshop will be organized to target industry, to help potential industrial partners to understand the potential applications of medical diagnostic results, develop business plans, and gain knowledge required to further develop versatile system based applications. Scientific, technical, and public environment will thus be informed and motivated by project results.

Success criteria:

- Number of technical and scientific meetings

1.2. Progress beyond the state-of-the-art

Describe the state-of-the-art in the area concerned, and the advance that the proposed project would bring about. If applicable, refer to the results of any patent search you might have carried out.

What follows is an analysis of existing approaches worldwide. The analysis to follow concludes the following: although the elaborated research examples do contribute a number of innovative approaches, none of them is holistic enough, to offer an integrated approach, which is where this proposal goes beyond state of the art. To clarify the point, the text to follow gives a small survey of the relevant issues and points to some state of the art research (the point is that only this proposal offers a holistic approach not existing in the state of the art research):

Skeletal muscles are the largest organ in the human body. Furthermore, they are the biggest consumer of energy and enable efficient movement at varying intensity and duration in different movement patterns. A healthy muscular system is associated with healthy

cardiovascular, pulmonary, immune (3) and endocrine systems (1, 2). Conversely, disorders of the neuromuscular system have dramatic effects on daily activities and independence (1).

Beneficial health effects of exercise (enabled through the muscular activity) have important roles in the protection against diseases associated with low-grade inflammation, such as cardiovascular diseases, type 2 diabetes, symptoms related to the metabolic syndrome and cancer (4). Also, muscle activity and resistance training can initiate some anti aging effects (6). Furthermore, resistance exercise training can reduce markers of oxidative stress, and increase anti-oxidant enzyme activity in older adults (7, 8).

Understanding such universal phenomena as movement or strength requires an understanding of the complete neuromuscular system (1).

Current methods for determination the mechanical and physiological properties of skeletal muscle are wide ranging and each have their pros and cons, but predominantly measure only a single component, which only defines how a muscle works at the particular test conditions. Furthermore, the majority of tests are done in a laboratory (9), constrained and often involve invasive methods (needle electromyogram, biopsy, maximum force measurement…).

Traditional measurement devices such as motion capture systems, force plates, and electromyography are adequate methods of gait analysis, but have several limitations, such as high cost and lack of portability (9).

Other established methods for measurement of muscle properties and musculoskeletal disorder also have some limitation:

Electromyography

The electromyogram (EMG) provides only an "intererferogram« that represents the summated electrical activation pattern of the muscle near the electrode. Since muscle force is highly dependent on length (due to the length-tension property) and velocity (due to the force-velocity property), electrical activity alone cannot possibly provide an accurate measurement of muscle force. In addition, since the EMG summates in a way that does not uniquely represent all of the motor units activated, EMG measurements that are used to infer force are highly suspect. (9, 20, 21; 22 a,b,c,d, 23).

One of the limitations of the interference EMG is the variability in the recording when the same task is performed by different subjects or by the same subject on different days. The two principal reasons for this variability are that the recording conditions change each time the electrodes are attached and the recording volume of the electrodes is usually less than the muscle mass involved in the task. (24)

Isokinetic dynamometry

It is generally impossible to measure force or torque of a particular muscle, thus all in task active muscle are measured (for example: knee extension measurement, force will be a composite generated by the vastus lateralis, vastus medialis, rectus femoris and gastrocnemius muscle…)

“Most isokinetic testing machines are good enough to keep the angular velocity constant during testing. However, detailed real-time studies of quadriceps muscles have shown that muscle fiber velocity and moment arm are basically never constant during the test. This means that it is extremely problematic to interpret isokinetic data in terms of the muscles generating the torque. The results from these types of studies are often vastly overstated and over-interpreted (9)”.

It is difficult to rigorously interpret torque-velocity data collected in isokinetic measurement, because a number of factors is typically unknown. These include the following:

- Muscle physiological cross-sectional area (PCSA).(25)
- The fraction of the muscle's PCSA that is activated. (28)
- Absolute moment arm as a function of joint angle and velocity.(26)
- Muscle fiber length as a function of joint angle and velocity.(27)
- Tendon length as a function of joint angle and velocity.(26)
- Inertial properties of the joint. (29)

These factors will be considered independently as the limitations of isokinetic dynamometers are presented.(9) Different approaches/technologies can diminish some of these limitations in musculoskeletal diagnostic.

How important are musculoskeletal disorders and their diagnostics for developed society?

Forty-seven of every 100 persons in the community between the ages of 25 and 75 possess a musculoskeletal disorder (10), and 14.4% have had persistent musculoskeletal pain for at least 1 month of the previous 12 months (11). Of these persons with musculoskeletal pain lasting at least 1 month, 82.7% consulted a health care professional about their pain, and 16.3% missed at least a single day of work due to their pain (11).

It is easy to surmise that such musculoskeletal disorders are costly. In fact, they have been reported to cost the United States $70 billion annually (12) and the EU (European Agency for Safety and Health at Work) estimates the economic costs at between 0.5% and 2% of GNP in 2000 (14, 15).

Our overall objective is to develop the technologies that go to make up and integrate Microsystems, and then produce specific medical/health devices to exploit these technologies.

Due to the prevalence and effects of musculoskeletal disorders, there is a profound need for accurate evaluation of functional capacity to assess treatment effectiveness, readiness to return to work, and financial claims. Currently, the accuracy of such evaluations is dependent upon the sincerity of effort exerted by the person being tested (13), which can significantly impact test validity.

In light of this, development of novel flexible, non-invasive technology with high sampling rates for simultaneously monitoring several phenomena of the neuromuscular system is crucial for more efficient and accessible diagnostics of musculoskeletal disorders. Same technology can be used to optimize musculoskeletal disorder recovery and rehabilitation.

Hence, building a multi-component non-invasive system which can be used to monitor unconstrained voluntary movement and acquires data on internal and external forces, reactions of the neuromuscular and muscular component for each individual muscle is a fitting aim. Additionally, it is and universal sensor that can be integrated into a network of these and enable whole new level of monitoring muscle and elucidating how muscle function at various physiological and environmental conditions.

More precisely DiaMus will simultaneously collect a wide array of data from working muscle:

physiological parameters (measurement of action potential in muscle fibres-sEMG, muscle fibre type distribution, local muscle fatigue, muscle potentiation, MU/muscle activation pattern…)

biomechanical parameters (time and amplitude parameters of muscle contraction, viscoelastic properties)

physical variables (the real time 3D position of measured body segment/muscle, acceleration, potentially: temperature, local skin humidity, blood oxygenation…)

There was a project from a similar field to ours in the 6FP (HEALTHY AIMS, Nano scale materials and sensors and Microsystems for medical implants improving health and quality of life, Action Line: IST-2002-2.3.1.2 Micro and nano-systems, Project Reference: 001837) (16). The proposal stated microsystem technologies and communication methods would be developed and bring intelligence directly to the human, in the form of medical implants and ambulatory measurement systems. The project was finished in 2008!

In contrast, we propose to build an inventive system with a much higher level of sensor component integration that enables unprecedented measurement of muscle mechanic properties during unconstrained voluntary movement. Additionally, the sensor element will be universal, thereby reducing production cost making more funds available for optimization and miniaturization.

Furthermore, the device can be conceptually connected with semantic web and the device principle will enable biofeedback and thereby movement optimization during walking,

running or other cyclic movement; autonomous operation and simultaneous analysis of correlations between muscle mechanic parameters, muscle output, neuromuscular input and forces (external-gravity and acceleration and internal-muscle contraction). In summary, this will make the approach to musculoskeletal disorder diagnostics and our understanding of muscle function more holistic and comprehensive.

Due to the projected small size of the sensor elements and utilization of wireless technology, it should not interfere with various types of movement or affect the biological system in any significant way. The applications of this innovative technology are wide-ranging, covering diverse fields like medical diagnostics, rehabilitation, kinesiology (monitoring and optimization of movement and motor learning) and pharmacology (to evaluate the local or systemic effects of novel drug compounds).

The DiaMus sensor network will be autonomous and the intelligent software/hardware can send data through the internet network intermittently or on-demand, this would enable remote monitoring of patients any time and optimize rehabilitation without requiring physical presence.

The musculoskeletal disorders and micro sensors have been chosen for 2 reasons. Firstly, they will progress the existing State of the Art in Microsystems/sensor networks in terms of size-function integration, reliability, and in addition, there will be a direct positive impact on the health and economy of EU citizens.

Estimates from EU Member States of the economic costs of all work related ill health range from 2.6 to 3.8% of Gross National Product (18) and a high proportion, up to 40-50% of the costs will be for musculoskeletal disorders (17). This means a coast between 215 to 314 billions EUR in EU in year 2008. (19,17).

Our leading principle for the DiaMus project is: More complementary information leads to better understanding of the problem and faster a solution.What follows are the references used for our survey of the relevant issues:

1. Skeletal Muscle Structure, Function and Plasticity: The Physiological Basis of Rehabilitation, Preference , LR Leiber, Lippincott Williams and Wilkins; 2nd Revised edition (2002).

2. Role of myokines in exercise and metabolism. Pedersen BK, Akerström TC, Nielsen AR, Fischer CP. J Appl Physiol. 2007 Sep;103(3):1093-8. Epub 2007 Mar 8. Review. 3. Skeletal muscle as an immunogenic organ. Nielsen S, Pedersen BK. Curr Opin Pharmacol. 2008 Jun;8(3):346-51. Epub 2008 Apr 15. Review.

4. Beneficial health effects of exercise--the role of IL-6 as a myokine. Pedersen BK, Fischer CP. Trends Pharmacol Sci. 2007 Apr;28(4):152-6. Epub 2007 Feb 28.

5. Does the aging skeletal muscle maintain its endocrine function? Steensberg A, Keller C, Osada T, Zacho M, Saltin B, Febbraio MA. Exerc Immunol Rev. 2004;10:42-55.

6. Aging, exercise, and muscle protein metabolism. Koopman R, van Loon LJ.

J Appl Physiol. 2009 Jun;106(6):2040-8. Epub 2009 Jan 8. Review.

7.Antioxidant enzyme activity is up-regulated after unilateral resistance exercise training in older adults. Parise G, Phillips SM, Kaczor JJ, Tarnopolsky MA. Free Radic Biol Med. 2005 Jul 15;39(2):289-95. Epub 2005 Apr 9.

8. Resistance exercise training decreases oxidative damage to DNA and increases cytochrome oxidase activity in older adults. Parise G, Brose AN, Tarnopolsky MA. Exp Gerontol. 2005 Mar;40(3):173-80.

9. Methods of running gait analysis.Higginson BK. Curr Sports Med Rep. 2009 May-Jun;8(3):136-41. Review.

10. Urwin M, Symmons D, Allison.T, et al. Estimating the burden of musculoskeletal disorders in the community: the comparative prevalence of

symptoms at different anatomical sites, and the relation to social deprivation. Ann Rheum Dis. 1998;57:649–655.

11. Magni G, Caldieron C, Rigatti-Luchini S, et al. Chronic musculoskeletal pain and depressive symptoms in the general population. An analysis of the 1st national health and nutritional examination survey data. Pain. 1990;43:299–307.

12. Brena S, Meacham A. Evaluation of function and disability. In: Bonica J, Loeser J, Chapman C R, eds. The Management of Pain. Philadelphia: Lea and Febiger; 1990:641–648.

13. Critical issues in the use of muscle testing for the determination of sincerity of effort. Robinson ME, Dannecker EA.Clin J Pain. 2004 Nov-Dec;20 (6):392-8. Review.

14. Factsheet 3 - Work related musculoskeletal disorders in Europe , European Agency for Safety and Health at Work , 01.02.2000

15. Work-related neck and upper limb musculoskeletal disorders, European Agency for Safety and Health at Work report and factsheet "WRULD : summary of Agency report", 2000.

16.http://cordis.europa.eu/fetch?CALLER=FP6_PROJ&ACTION=D&DOC=1&CAT=PROJ&QUERY=011985eed463:1a39:31777e09&RCN=74603

17. P. Paoli, Data from the European survey on working conditions - European Foundation for the Improvement in Living and Working Conditions, unpublished article, June 1999

18. "Economic impact of occupational safety and health in the Member States of the European Union" - Agency report, 1998

19. Nominal 2008 GDP for the world and the European Union.". World economic outlook database, April 2009. International Monetary Fund. Retrieved 2009-04

20. Gerilovsky L, Tsvetinov P, Trenkova G. Peripheral effects on the amplitude of monopolar and bipolar H-reflex potentials from the soleus muscle. Exp Brain Res. 1989;76(1):173-81.

21. Bigland-Ritchie B. EMG/force relations and fatigue of human voluntary contractions. Exerc Sport Sci Rev. 1981;9:75-117

22. a Hof AL, Van den Berg J. EMG to force processing I: An electrical analogue of

the Hill muscle model. J Biomech. 1981;14(11):747-58.

22. b Hof AL, Van den Berg J. EMG to force processing II: Estimation of parameters of the Hill muscle model for the human triceps surae by means of a calfergometer.J Biomech. 1981;14(11):759-70.

22. c Hof AL, Van den Berg J. EMG to force processing III: Estimation of model parameters for the human triceps surae muscle and assessment of the accuracy by means of a torque plate. J Biomech. 1981;14(11):771-85.

22.d Hof AL, Van den Berg J. EMG to force processing IV: Eccentric-concentric contractions on a spring-flywheel set up. J Biomech. 1981;14(11):787-92.

23. Milner-Brown HS, Stein RB. The relation between the surface electromyogram and muscular force. J Physiol. 1975 Apr;246(3):549-69

24. Enoka RM. 2002. Electromyography, 46-55. Neuromechanics of human movement.Champaign, USA: Human Kinetics.

25. Fukunaga T, Roy RR, Shellock FG, Hodgson JA, Day MK, Lee PL, Kwong-Fu H, Edgerton VR. Physiological cross-sectional area of human leg muscles based on magnetic resonance imaging. J Orthop Res. 1992 Nov;10(6):928-34

26. Ito M, Akima H, Fukunaga T. In vivo moment arm determination using B-mode ultrasonography. J Biomech. 2000 Feb;33(2):215-8.

27. Ichinose Y, Kawakami Y, Ito M, Kanehisa H, Fukunaga T. In vivo estimation of contraction velocity of human vastus lateralis muscle during "isokinetic" action. J Appl Physiol. 2000 Mar;88(3):851-6.

28. Enoka, R.M., Fuglevand, A.J. (1993). Neuromuscular basis of the maximum voluntary force capacity of muscle. In M.D. Grabiner (Ed.) Current Issues in Biomechanics (pp. 215-235). Champaign, IL

1.3. S/T methodology and associated work plan

1.3.1. Describing the overall strategy of the work plan

Note that the major organizational point of this proposal is to link project objectives and work packages (each project objective is encapsulated into a separate work package); also, success criteria and milestones (major activity at each milestone is to check if the success criteria are satisfied).

Extremely important to keep in mind when evaluating this proposal is:

Since each project objective is encapsulated into a different work package (WP), the number of WPs is higher than usual, and that fact may be used against the proposers. However, the authors of this proposal strongly believe that each issue of importance has to be kept track of separately, for the best control of details and related finances.

Since success criteria are applied at all milestone points, special attention is dedicated to mechanisms that have to guarantee success, in conditions when a majority of funding is meant to go to WB (Western Balkans) countries, which do not represent the technologically highest peaks of Europe. In spite of the fact that some WP leaders of this proposal, now living and working in WB, have created in the past some of the scientific and technological peaks in the USA and EU, it still may happen that some of the reviewers of this proposal get sceptical.

Consequently, this proposal includes a serious partner from a highly respected EU institution responsible for quality control, and continuous on-line checking of progress on all tasks, on the monthly basis.

A relatively large number of partners from WB (Western Balkans) is selected, so that more can be done for less money. On the other hand, the partners were chosen with considerable experiences from West, so that the quality is maintained at the highest level.

Since the dissemination of project results is an Achilles' heal of most research and development projects, we have dedicated three different WPs to dissemination in the widest sense (WP7 to inform the scientific and technical community about the generated project results, WP8 to create impact on related businesses). Also, a special partner, with experience in making business plans for market, is incorporated, to help entrepreneurial the vision of this proposal (i.e., turn it into a product for the market, in an entrepreneurial way).

Since a PoC (Proof of Concept) implementation is a condicio sine qua non for this type of innovative efforts, special attention is dedicated to the testing of the PoC implementation and its applications (by PoC implementation, here we assume an implementation of a highly reduced subset system, which is applicable to real world situations, and can help prove the applicability of the concept in real world scenario of interest for the final application).

In order to achieve the overall project objectives, the following items are considered as crucial:

- Competent researchers well aware of the state of the art in the research field and able to take the research forward;
- State of the art research infrastructure
- Ability to work, communicate and collaborate with researchers from various backgrounds, in various circumstances and environments;
- Large network of contacts in the research community;
- Public awareness of the benefits of the research in a chosen field and promotion of research results and achievements.

The project is organized in 11 work packages as follows:

- WP0 Project management
- WP1 Definition of use case scenario
- WP2 Definition of the system architecture
- WP3 Adding intelligence to the WSN system
- WP4 Development of hardware, communications, and software platform, for the full blown system

- WP5 Development of a PoC, as a subset system
- WP6 Testing of the PoC in real-life scenario
- WP7 Informing the scientific and technical environment
- WP8 Impact on the environment

The main body of work is included in six work packages (WP1, 2, 3, 4, 5, and 6). The activities planned in these work packages correspond to the main strands of the project as described above. It is the responsibility of the project management team (WP0) to coordinate these activities to maximize the impact and benefits for everyone involved. Work packages WP7, 8, 9, and 10 are treated as pillars that support the main body of work.

WP0 or Project management, is, as the name implies, responsible for the overall project management, coordination of all project activities and managing relationship with stakeholders. The project management team will comprise administrative (BGDUNI) and scientific & technical management project manager (TMG).

The former one will be responsible for progress monitoring, task distribution, financial matters, submission of deliveries, risk assessment, stakeholder management and compliance with the EU Commission requirements. Prof. Veljko Milutinovic (BGDUNI) as an experienced project manager that has managed a number of international projects and activities (including the world's first GaAs 200MHz microprocessor for DARPA, about a decade before Intel) will take this role. So far, he was involved in 4 different FP6 projects and 4 different FP7 projects. Two of them were dedicated to the major two themes of this proposal: One of them was dedicated to wireless sensor networks (ProSense with Ericsson, Ireland) and another one to concept modelling (Socratenon with University of Salerno, Italy).

The later one will be run by Dr. Bostjan Simunic (TMG) who will take the S&T manager role. He has an extensive national and international experience. The S&T manager will be responsible for the scientific direction of the project including the strategy of all developments, as well as the definition of the content of the project sponsored workshops and seminars, identification of and interaction with the world leading researchers for the competence areas required by the project, and (re)presentation of the project and the network of participating organizations at public events.

1.3.2. The timing of the different WPs and their components (Gantt chart or similar).

TASK NAME / YEAR 1 MONTH	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	
WP0 Semi-annual progress report						X							
WP0 Semi-annual progress report												X	
WP0 Semi-annual progress report													
WP0 Semi-annual progress report													
WP0 Semi-annual progress report													
WP0 Semi-annual progress report													
WP0 Final report													
WP1 Development of applications of interests, in six Aws	X	X	X	X	X	X							
WP1 Definition of CSP and EPP parameters to monitor	X	X	X	X	X	X							
WP2 HW infrastructure	X	X	X	X	X	X	X	X	X				
WP2 Communications infrastructure	X	X	X	X	X	X	X	X	X				
WP2 SW infrastructure	X	X	X	X	X	X	X	X	X				
WP3 Definition of KEP procedures	X	X	X	X	X	X	X	X	X				
WP3 Definition of CEA algorithms	X	X	X	X	X	X	X	X	X	X	X	X	
WP3 Definitions of RRG generators	X	X	X	X	X	X	X	X	X	X	X	X	
WP4 Hardware and communications design										X	X	X	
WP4 Software design													

WP5 Architecture and design in CMMI and system schemes of the subset to implement										X	X	X
WP5 Programming of the applications, Version #1												
WP5 Testing Version #1, and generation of Version #2												
WP6 Testing in Slovenia												
WP6 Testing PoC in SLO conditions												
WP6 Testing in Serbia												
WP6 Comparison and suggestions for product for market (PfM)												
WP7 Kick-off meeting	X											
WP7 The first annual workshop (partners only)						X						
WP7 The first annual symposium (partners and beyond)												X
WP7 The second annual workshop												
WP7 The second annual symposium												
WP7 The third annual workshop												
WP7 The third annual symposium with closing discussion												
WP8 Informing the environment via media	X	X	X	X	X	X	X	X	X	X	X	X
WP8 Search for investors to turn PoC into a market product	X	X	X	X	X	X	X	X	X	X	X	X

WP8 Organization and monitoring of talks and business plans for PfM investors	X	X	X	X	X	X	X	X	X	X	X	X
WP8 Supervision of impact on the social environment	X	X	X	X	X	X	X	X	X	X	X	X

TASK NAME / YEAR 2 MONTH	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
WP0 Semi-annual progress report												
WP0 Semi-annual progress report												
WP0 Semi-annual progress report						X						
WP0 Semi-annual progress report												X
WP0 Semi-annual progress report												
WP0 Semi-annual progress report												
WP0 Final report												
WP1 Development of applications of interests, in six AWs												
WP1 Definition of CSP and EPP parameters to monitor												
WP2 HW infrastructure												
WP2 Communications infrastructure												
WP2 SW infrastructure												
WP3 Definition of KEP procedures												
WP3 Definition of CEA algorithms												

WP3 Definitions of RRG generators												
WP4 Hardware and communications design												
WP4 Software design	X	X	X	X	X	X						
WP5 Architecture and design in CMMI and system schemes of the subset to implement												
WP5 Programming of the applications, Version #1	X	X	X	X	X	X						
WP5 Testing Version #1, and generation of Version #2							X	X	X	X	X	X
WP6 Testing in Slovenia												
WP6 Testing PoC in SLO conditions												
WP6 Testing in Serbia												
WP6 Comparison and suggestions for product for market (PfM)												
WP7 Kick-off meeting												
WP7 The first annual workshop (partners only)												
WP7 The first annual symposium (partners and beyond)												
WP7 The second annual workshop						X						
WP7 The second annual symposium												X
WP7 The third annual workshop												
WP7 The third annual symposium with closing discussion												

WP8 Informing the environment via media	X	X	X	X	X	X	X	X	X	X	X	X
WP8 Search for investors to turn PoC into a market product	X	X	X	X	X	X	X	X	X	X	X	X
WP8 Organization and monitoring of talks and business plans for PfM investors	X	X	X	X	X	X	X	X	X	X	X	X
WP8 Supervision of impact on the social environment	X	X	X	X	X	X	X	X	X	X	X	X

TASK NAME / YEAR 3 MONTH	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	
WP0 Semi-annual progress report													
WP0 Semi-annual progress report													
WP0 Semi-annual progress report													
WP0 Semi-annual progress report													
WP0 Semi-annual progress report						X							
WP0 Semi-annual progress report												X	
WP0 Final report												X	
WP1 Development of applications of interests, in six AWs													
WP1 Definition of CSP and EPP parameters to monitor													
WP2 HW infrastructure													
WP2 Communications infrastructure													

WP2 SW infrastructure												
WP3 Definition of KEP procedures												
WP3 Definition of CEA algorithms												
WP3 Definitions of RRG generators												
WP4 Hardware and communications design												
WP4 Software design												
WP5 Architecture and design in CMMI and system schemes of the subset to implement												
WP5 Programming of the applications, Version #1												
WP5 Testing Version #1, and generation of Version #2												
WP6 Testing in Slovenia	X	X	X	X	X	X	X	X	X	X	X	
WP6 Testing PoC in SLO conditions	X	X	X	X	X	X	X	X	X	X	X	
WP6 Testing in Serbia	X	X	X	X	X	X	X	X	X	X	X	
WP6 Comparison and suggestions for product for market (PfM)	X	X	X	X	X	X	X	X	X	X	X	
WP7 Kick-off meeting												
WP7 The first annual workshop (partners only)												
WP7 The first annual symposium (partners and beyond)												
WP7 The second annual workshop												
WP7 The second annual symposium												

WP7 The third annual workshop						X						
WP7 The third annual symposium with closing discussion												X
WP8 Informing the environment via media	X	X	X	X	X	X	X	X	X	X	X	X
WP8 Search for investors to turn PoC into a market product	X	X	X	X	X	X	X	X	X	X	X	X
WP8 Organization and monitoring of talks and business plans for PfM investors	X	X	X	X	X	X	X	X	X	X	X	X
WP8 Supervision of impact on the social environment	X	X	X	X	X	X	X	X	X	X	X	X

WP0: Project management

Tasks#01-06: Semi-annual progress reports (R)

Deliverables#01-06: Report (each six months)

M36

Task#07: Final report

Deliverable#07: Progress report of the whole project

WP1: Definition of use case scenarios

M1-M6

Task#01: Development of applications of interests, in six AWs

Deliverable#01: R (rationales and functionalities)

M1-M6

Task#02: Definition of CSP and EPP parameters to monitor

Deliverable#02: R (list of parameters and their definitions)

WP2: Definition of the system architecture

M1-M9

Task#01: HW infrastructure

D: Report on HW built into the system

M1-M9
Task#02: Communications infrastructure
D: Report on Communication system built in the system

M1-M9
Task#03: SW infrastructure
D: Report on SW built into the system

WP3: Adding intelligence to the system

M1-M9
Task#01: Definition of KEP procedures
Deliverable#01: Report (procedural details)

M1-M12
Task#02: Definition of CEA algorithms
Deliverable#02: Report (algorithmic details)

M1-M12
Task#03: Definitions of RRG generators
Deliverable#03: Report (decision making details)

WP4: Development of hardware, communications, and software platform, for the full blown system

M10-M12
T.01: Hardware and communications design
D.01: Schematics

M13-M18
T.02: Software design
D.02: Documentation (D), in-block and in-line

WP5: Development of a PoC, as a subset system

M10-M12

T.01: Architecture and design in CMMI and system schemes of the subset to implement
D.01: CMMI and system schemes

M13-M18
T.02: Programming of the applications, Version #1
D.02: Documented code

M19-M24
T.03: Testing Version #1, and generation of Version #2
D.03: Documented testing procedures and final code documented

WP6: Testing of the PoC in real-life scenario

M25-35
T.01: Testing in Slovenia
D0.1 (M34) – Report on testing results in Slovenia

M25-35
T.02: Testing PoC in SLO conditions
D0.2 (M35) – Report on testing results in Slovenia

M25-35
T.03: Testing in Serbia
D0.3 (M35) – Report on testing results in Slovenia

M25-35
T.04: Comparison and suggestions of product for market
D.04 (M36) Proposal for product development oriented to mass markets

WP7: Informing the scientific and technical environment
M1
Task#01: Kick-off meeting
Deliverable#01: Set of Rs by partners on planned activities

M6
Task#02: The first annual workshop (partners only)
Deliverable#02: Number of papers (Ps) written for the first annual workshop

M12

Task#03: The first annual symposium (partners and beyond)
Deliverable#03: Number of papers (Ps) written for the first annual symposium

M18
T.04: The second annual workshop
D.04: Number of papers (Ps) written for the second annual workshop

M24
T.05: The second annual symposium
D.05: Number of papers (Ps) written for the second annual symposium

M30
T.06: The third annual workshop
D.06: Number of papers (Ps) written for the third annual workshop

M36
T.07: The third annual symposium with closing discussion
D.07: Number of papers (Ps) written for the third annual symposium

WP8: Impact on the environment

Although not typical, this project likes to have different work packages to organize and monitor effects of technical and scientific meetings, on one hand, and public dissemination with preparation of a business plan for a market product and search for investors, on the other hand.

M1-M36
T.01: Informing the environment via media
D.01: List of public appearances for dissemination purposes, and content there-offs
M1-M36
T.02: Search for investors to turn PoC into a market product
D.02: List of investor contact and presentations made.

M1-M36
T.03: Organization and monitoring of talks and business plans for PfM investors
D.03: List of brainstorming meetings, and contents there-offs.

M1-M36
T.04: Supervision of impact on the social environment

D.04: List of in-house talks and brainstorming meetings, and contents there-offs.

1.3.3. Detailed work description is broken down into work packages

WP1, Definition of use case scenario, is one of the main pillars of the project. It is the responsibility of this package to provide access to the latest body of wireless sensor related knowledge available in the world and to use it in order to develop all the use cases of interest (at least 20 different ones). Leading researchers in the field of systematic application of formal methods in medical diagnostics will be invited to take part. This WP ensures that all information needed for the following WPs is clearly defined.

WP2, is focused on developing of the system full blown architecture, encompassing thus the state-of-the-art in medical diagnostics. It is based on design of the system infrastructure, test platform, and information flow in the system, in order to cover major concepts behind this proposal, which is to connect synergistically the following fields: WSN (wireless sensor networks), 3G (mobile telephony), INT (Internet technology), SEM (software engineering methodology), IDE (integrated digital economy), DMS (data mining systems), SWS (semantic web systems) and CAI (conceptual artificial intelligence); all that for better servicing in the ME (medical economy), QoS (quality of service) improvement in medical diagnostics, and QoL (quality of life) improvement for workforce in medicine.

This WP is focused on proposing the system architecture which should be capable to integrate various input data from different sources and communication channels (WSN, mobile networks, various Internet services) and in the same time to provide an easy interface for several building blocks responsible for applying intelligent algorithms on collected data in order to provide to the users a valuable information depend on relevant parameters. Collected information from providers through various communication channels should be stored in an uniform manner, and then retrieved and searched by various higher components as software agents which monitor the processes and events in the system, central data mining system (DMS) trying to predict requests to the system and hence response (ideas), concept modelling analyzer which analyzes statistics of used idioms and then creates concepts which is used for querying the system. Hardware requirements are considered for system built, as well as possible hardware devices for usage from students and teachers. Also, this system will be more usable for the users, if it is able to provide valuable information via different communication protocols and to format information respecting multiple standards. Therefore, potential communication protocols are specified. Similarly, export or import data from other systems is important part and it will be specified in this WP. Various software platforms will be considered either for implementation of suppliers of information (sensor nodes…) or for consumers (mobile phones). Generally, all internal interfaces and connections will be specified in this WP, as well as interface for future possible extensions.

WP3, Adding intelligence to the system, is focused on improvements and upgrades of the research infrastructure that bring elements of intelligence into the system. It is the aim of this WP to set up a state of the art research platform that will provide environment for efficient

execution of research activities, including performing modelling, simulations, emulations, implementation of proofs of concept and prototyping. With parallel development in two centers (Ljubljana and Belgrade), in combination with the selected and case-oriented AW networks and with the support given from the EU partner centers, research issues on system intelligence will be explored and tested. General communication and computing equipment is readily available in the targeted centers and is regularly being updated, so it is expected that the main improvements will have to be made in regard to the tools specific for the task of adding intelligence to the system in six detailed application use cases. See Appendix 3 for an example and Appendix 4 for a concept modeling survey.

WP4, Design of the hardware, communications, and software platform, for the full blown system, along the lines specified in the main objectives of DiaMus.

This WP will be devoted to the implementation of the system structure, fulfilling the specification defined in WP3 and designed by software tools that will enable formal verification and testing. The whole system architecture is based on the foundations of the well elaborated distributed systems theory. Calculation and storage resources are distributed and can change even change their location. System input/output data are mostly related to the user interfaces and therefore characterized with significant mobility. Available interconnection technologies will be used for communication infrastructure. Some amount of hardware design is envisaged in wireless communication among some low level system components (sensors, personal terminals, etc.). Existing open-source software components will be used mostly in the system design. Newly developed SW components will be based on object oriented approach and designed with clearly specified input/output interfaces that enable reusability and upgrading. During testing period we will introduce some simplifications and assumptions, like centralized or at least synchronized data storage, admissible time delays after user requests etc. in order to develop exemplar PoCs defined in WP5. See Appendix 2 for more details.

WP5, Development of a PoC, as a subset system, along the target goals specified in the main objectives of DiaMus.

WP6, Testing of the PoC in real-life scenario, focuses on particular installation of the subset system at two hospitals, where testing in real conditions will be used as a proof of system concept reliability. This will highly improve the socio-economic impact of the project and open the possibilities for concrete cooperation with SMSs in the region and abroad. If it is found necessary, retesting at smaller hospitals will be organized, too. Thus, the possibilities for future cooperation can take place.

WP7, Informing the scientific and technical environment is focused on two things: promotion of the project and its participants, particularly research centers from EU and raising general public and industry awareness of the potential benefits of deployment and exploitation of the research results.

WP8, Impact on the environment is focused on organization and monitoring of project impact on scientific and technical environment.

This WP focuses on the cross-fertilization between scientific results of the project and the potential business interest of entrepreneurs, investors and companies to achieve the maximum dissemination through in-house talks, brainstorming meetings, seminars, summer schools and special sessions in EU. The event series will be of two kinds: Open Research Days in scientific areas of the project and Open Innovation Days. The first kinds of events will monitor the advances in research done and these events will help to select potential key technologies implemented in the project to create new products and services. The second kind of events will be oriented to generate interest of scientific entrepreneurs to exploit disruptive technology in new markets. The results of synergy between these two event series will measure the impact on the environment to spot the commercial potential of the project technology.

This WP will give an overview of the markets and technologies involved in the PoC and also the business plan to support exploitation of it. From Wireless Sensor Networks (WSN), Sports Medicine Systems (SMS), Electrical and Computer Engineering (ECE), Internet technology (INT), Data Mining systems (DMS), Conceptual Artificial Intelligence (CAI), Semantic Web Systems (SWS), all the value chain will be analyzed and major players identified. Previous experiences in routes to exploit Wireless Sensor Networks in several domains will be studied and compared with their corresponding business models. The result will be a detailed business plan to help to understand the business size, opportunities and threats.

1.3.3.a. Work package list

Work package No	Work package title	Type of activity	Lead partic.No	Lead partic. short name	Person-months	Start month	End month
WP0	Project management	MGT	2		35	M1	M36
WP1	Definition of use case scenarios	RTD	1		50	M1	M6
WP2	Definition of the system architecture	RTD	4		85	M1	M9

WP3	Adding intelligence to the WSN system	RTD	1		70	M1	M12
WP4	Development of hardware, communications, and software platform, for the full blown system	RTD	3		65	M10	M18
WP5	Development of a PoC, as a subset system	RTD	5		35	M10	M24
WP6	Testing of the PoC in real-life scenario	RTD	3		120	M25	M35
WP7	Informing the scientific and technical environment	DEM	1		70	M1	M36
WP8	Impact on the environment	DEM	9		70	M1	M36
	TOTAL				600		

1.3.3.b. Deliverables list

Del. no.	Deliverable name	WP no.	Nature	Dissemination level	Delivery date (project month)

D0.1	Progress report for the six months of work	0	R	PU	M6
D0.2	Progress report for the six months of work	0	R	PU	M12
D0.3	Progress report for the six months of work	0	R	PU	M18
D0.4	Progress report for the six months of work	0	R	PU	M24
D0.5	Progress report for the six months of work	0	R	PU	M30
D0.6	Progress report for the six months of work	0	R	PU	M36
D0.7	Progress report of the whole project	0	R	PU	M36
D1.1	Rationales and functionalities	1	R	PU	M6
D1.2	List of parameters and their definition	1	R	PU	M6
D2.1	Report on HW built into the system	2	R	PU	M9
D2.2	Report on Communication system built in the system	2	R	PU	M9
D2.3	Report on SW built into the system	2	R	PU	M9
D3.1	Procedure details	3	R	PU	M9
D3.2	Algorithmic details	3	R	PU	M12
D3.3	Decision making details	3	R	PU	M12
D4.1	Schematics	4	R	PU	M12
D4.2	Documentation, in-block and in-line	4	R	CO	M18
D5.1	CMMI and system schemes	5	R	CO	M12
D5.2	Documented code	5	R	CO	M18
D5.3	Documented testing procedures and final code documented	5	R	CO	M24
D6.1	Report on testing results in Slovenia - Ljubljana	6	R	PU	M34

D6.2	Report on testing results in Slovenia - Koper	6	R	PU	M34
D6.3	Report on testing results in Serbia	6	R	PU	M34
D6.4	Proposal for product development for mass market	6	R	PU	M35
D7.1	Set of Rs by partners on planned activities (Ps) written for the	7	R	PU	M1
D7.2	Number of papers (Ps) written for the first annual workshop	7	R	PU	M6
D7.3	Number of papers (Ps) written for the first annual symposium	7	R	PU	M12
D7.4	Number of papers (Ps) written for the second annual workshop	7	R	PU	M18
D7.5	Number of papers (Ps) written for the second annual symposium	7	R	PU	M24
D7.6	Number of papers for third annual workshop	7	R	PU	M30
D7.7	Number of papers (Ps) written for the third annual symposium	7	R	PU	M36
D8.1	List of public appearances for dissemination purposes, and content there-offs	8	R	PU	M36
D8.2	List of investor contact and presentations made.	8	R	PU	M36
D8.3	List of brainstorming meetings, and contents there-offs.	8	R	PU	M36

D8.4	List of in-house talks and brainstorming meetings, and contents there-offs.	8	R	PU	M36

1.3.3.c. List of milestones

Milestones are control points where decisions are needed with regard to the next stage of the project.

Milestone number	Milestone name	Work package(s) involved	Expected date	Means of verification
M0.1	Checking on optimization of the reporting processes involved in the project (deadlines)	WP0	M12	
M0.2	Checking on optimization of the control processes involved in the project	WP0	M24	
M0.3	Checking on optimizing finances of the project	WP0	M36	
M1.1	Checking on opinion of related-businesses on the need for the generated applications, based on their knowledge about where the major unnecessary expenses are	WP1	M6	
M1.2.	Checking on opinion of related-businesses about the functionalities provided	WP1	M6	
M1.3	Checking on opinion about optimal values of parameters involved	WP1	M6	
M2.1	Checking on potential speed of processing and communications	WP2	M9	

M2.2	Checking on SW and HW architecture which permits easy expandability	WP2	M9	
M2.3	Checking on compatibility with existing platforms	WP2	M9	
M3.1	Checking on the number of CSP and EAP parameters defined, for a holistic coverage of the issues of importance	WP3	M9	
M3.2	Checking on the number of application scenario for which the KEP, CEA, and RRG are developed	WP3	M12	
M3.3	Checking on compatibility of the developed KEP, CEA, and RRG with the underlying architecture	WP3	M12	
M4.1	Checking on hardware, minimal transistor count	WP4	M18	
M4.2	Checking on communications, maximal flexibility	WP4	M18	
M4.3	Checking on software, error-free structure easy to expand with plug-in software.	WP4	M18	
M5.1	Checking on smart reduction of functionalities so that all planned experiments can be successfully performed and the PoC prototype implemented in time and without bugs	WP5	M12	

M5.2	Checking timely implementation	WP5	M18	
M5.3	Checking implementation without bugs	WP5	M24	
M6.1	Checking on test cases developed according to the needs of the beneficiary industry	WP6	M35	Web site accessible on Internet
M6.2	Checking on specification of issues to compare which takes country specifics into consideration	WP6	M35	Exploitation workshop held with industry participation
M6.3	Checking on details of the requirements for industrial prototype to follow.	WP6	M35	
M7.1	Checking on number of papers presented at internal workshops and the number of papers with potentials to get accepted for publication in SCI journals	WP7	M36	
M7.2	Checking on number of participants at workshops, one a year, for three years (min 20 participants per workshop)	WP7	M36	
M7.3	Checking on number of participants at scientific symposia, one a year, for three years (minimal 40 per symposium)	WP7	M36	

M7.4	Checking on number of public presentations in media (one per months, for three years), with potential partners and representatives of future spin-off companies	WP7	M36	
M8.1	Checking the techno economical impact of the final product in the market environment	WP8	M36	

1.3.3.d. Description of each work package

Work package number	0	Start date or starting event:			Beginning of M1					
Work package title	Project management									
Activity Type	MGT									
Participant number	1	3	7	10						Total
Participant short name	TMG	FERRARA	SPACE	BSC						
Person-months per participant:	15	5	5	10						35

Objectives

The objectives of WP1 are the overall management, progress monitoring and stakeholders management of the project. WP1 aims at:

Setting up, operating and maintaining the project administrative and scientific management infrastructure.

Ensuring the overall scientific and technical coordination of the project.

Ensuring collaboration and coordination with relevant government bodies regarding research programmes

Performing a self-assessment of the project progress.

Conducting progress reviews on M6, M12, M18, etc (every 6 months)

Description of work

WP Leader: TMG

T0.1- T0.6 – Semi-annual progress reports (TL: TMG)

The Project Manager (PM) will be the permanent responsible person for interface towards the Commission and partners of the Consortium for all administrative, contractual and financial matters and handle the overall management of the project. The duties, methodologies, IPR, conflict resolution and management strategies that will be followed in the project are described in detail elsewhere in this proposal. The project manager will submit all deliverables and reports to the Commission, including contractually obligatory reports (periodic management and activity reports, final management and activity report, audit certificates – not referenced as deliverables), an intermediate project report and the Final Project Report. The project manager will maintain the project plan. The exchange of researchers is a crucial issue, both in the initial phases when final set of use cases and related details have to be created, and later on during the implementation and testing. All these exchange visits have to be carefully planed, and their costs carefully minimized. The purchase of each and every detail needed for the success of this project has to be monitored carefully, to avoid errors from some other past projects in which resources were wasted on non-adequate purchases. Also, all purchases have to be selected so that they are usable and after the project is over, for educational purposes at universities involved.

T0.7 – Final report (TL: TMG)

The Scientific and technical co-ordination of the project will be under the responsibility of the Scientific and technical manager and under the guidance of the project's Operational Steering Group (OSG). The S&T manager will maintain the Project handbook which will contain the schedule and scientific content of all project events (workshops, seminars, summer schools, research exchanges). The duties and S&T management strategies that will be followed in the project are described in detail elsewhere in this proposal.

Deliverables

D0.1 – D0.6 (M1 – M6; M7 – M12;…) – Progress report for the six months of work

D0.7 (M36) – Progress report of the whole project

Work package number	1		Start date or starting event:						Beginning of M1	
Work package title	Definition of use case scenarios									
Activity Type[12]	SUPP									
Participant id	1	2	3	7	9					Total
Participant short name	TMG	BGDUNI	FERRARA	SPACE	FRI					

Person-months per participant:	15	20	5	5	5					50
Objectives To define use case scenarios for six selected applications in medicine To facilitate transfer of the S&T competence and knowledge among partners To enable information exchange and sharing between all project partners, including external experts To provide opportunities for people networking, in particular for young researchers To establish a joint supervision program focusing on the success of the project.										

WP Leader: TMG

Description of work

This work package will focus on knowledge transfer primarily among project participants with involvement of external experts. Some of the knowledge transfer activities will be available to public and can be considered as dissemination activities as well. Research workshops and seminars will be organized and the DiaMus Excellence Award will be established to honor the best achievements.

T1.1 Development of applications of interest, in six AWS (TL: TMG) – The details of the six different applications will be developed, and a workshop will be held during M1 or M2 in Ljubljana and will be hosted by TMG Slovenia, to present the results. Agenda for the first workshop is as follows:

Presentation of each partner's research activities and research results.

Tutorial on system approach to medical-diagnostics by Srdjan Djordjevic

Overview of complex medical diagnostics related research and projects funded by the NSF, by an US expert to be determined

Research on WSN sensors and actors and mobile sensing platforms in medical diagnostics will be presented by an invited expert speaker to be determined.

The second activity will be a seminar held in Belgrade, Serbia, in M4 or M5. The theme of the seminar is *Elaboration of the AWs for typical Use-Case in Networked Medical Analysis*. Location: Belgrade, Serbia. Topics that should be elaborated (but not limited to) are:

Overview of the generated results

Sensors and actors generated data in medicine (WSN)

Internet generated data in medicine (INT)

Acquisition of products data in medicine (PD)

Services data in medicine (SV)

Human resource data (HR)

Novel ideas (NI)

Tutorials and lectures will be given by researchers from the project partners and external experts. Additional ex-project members active in this field will be invited as well. Main aspects of the deliverable are: Details of functionalities of chosen applications. Development of requirement specifications. Adversities of use cases. Indications for QoL, QoS, and RoS parameters.

T1.2 Definition of CSP and EPP parameters to monitor (TL: TMG) – Definition of parameters of importance for CSP and EAP. Definitions will be created to support the six applications of interest.

Deliverables

D1.1 (M1 – M6) – Rationales and functionalities

D1.2 (M1 – M6) – List of parameters and their definitions

Work package number	2			Start date or starting event:					Beginning of M1	
Work package title	Definition of the system architecture									
Activity Type[12]	SUPP									
Participant id	1	2	3	7	8					Total
Partic. Short name	TMG	BGDUNI	FERRARA	SPACE	FE					
Person-months per participant:	15	30	30	5	5					85

Objectives

The main objective of this WP is to create the system architecture that should enable integration of various input data from different sources and communication channels, while providing an easy interface for several building blocks responsible for applying intelligent algorithms on collected data in order to provide to the users valuable information depend on relevant parameters. The specific goals are:

Specification of internal data format for collected input data, interface among components, specification for integration(translation/adaptation) of input data source, specification for possible future extension of the system

Consideration and specification of necessary hardware requirements for system built as well as required hardware devices used for providing input data or for interaction with the system

Specification of necessary communication protocols and standards that will be used for gathering the input data, receiving requests and for publishing response of the system, and for exchanging (exporting and importing) data with other systems

Consideration and specification of used software platforms for developing agents that generates input data, software technologies and frameworks for user interaction

Description of work

WP Leader: BGDUNI

T2.1 HW Infrastructure (TL: BGDUNI) – The common idea is to use the standard hardware for core implementation of this system. That means that most of the system should run on typical server hardware that is capable to satisfy performance and storage requirements. The only exception is the specific hardware for the potential acceleration of certain blocks (DMS) that will be implemented with FPGA technology, if analysis shows that this acceleration is necessary. Also, in this task it will be considered all hardware devices (sensor nodes, mobile and smart phones...) that could be either provider of input data for the system, or just used for interaction with the users (display of information, request for information). Outcome of this task is important for specification of communication infrastructure in T2.2 as well as for software specification in T2.3. As a result of activities in this task, it will be create the report that discusses all hardware devices considered for using in this project, with specification of hardware requirements necessary for system built and specific acceleration hardware.

T2.2 Communications infrastructure (TL: BGDUNI) – This system architecture should support integration with input data suppliers through different communication channels, and in the same time to provide response to the users via various communication protocols and standards. This list of communication channels and protocols includes WSN protocols (ZigBee, Bluetooth, IEEE 802.15.4, or its modifications), mobile oriented services (GSM, SMS, GPRS, alarms, pagers), Internet services (Cloud, GIS, Finances, Digital Marketing, public available web services). In the same time it is necessary to publish information through wide possible protocols and standards (HTML, WML, web services, RDF, REST). Since this list of communication protocols could be very long, the main objective of this task is to specify principle mechanism of connecting various data sources (communication protocols and standards) to our system using plug-in mechanism. Practically, it is a definition how to interpret received data and to store them to the internal unified format enabled for later searching and retrieving from higher blocks in the architecture. Similarly, necessary protocols and formats for publishing customer information should be specified. Typically, this should include a well known format as HTML, WML, specification for offered web services, specification for the semantic web structured data, description of the alerting or subscribing services on certain information through asynchronous web services and similar. In order to achieve interoperability with other systems, it will be consider formats with semantically annotated data that is suitable for an easy exchange of information (RDF). The outcome of this task is in correlation with the results of WP1 (use case analysis) and also with T2.1. and T2.3. The result of this task is the report with the specification of communication channels and protocols used for input and output to our system.

T2.3 SW Infrastructure (TL: BGDUNI) – The objective of this task is to specify all necessary software components and interfaces among them, while considering all software platforms that could be used. This system consists of several software components each responsible for different tasks. The common idea for the system architecture is to use service oriented architecture. But, as a common ground and most likely the most important part of the whole system is the system integration layer, responsible for integrating of all available sources of data while storing collected data in the common data format. Experience from the previous projects (semantic sensor layer - integration of sensor networks in Prosense FP7 project) will help in specification of this part. The idea is to use data format which saves data values, but also keeps additional information (time, location, and others), and also data about data types which is stored in appropriate meta data. With this approach, collected data could be retrieved and semantically searched using an easy and uniform interface, which hides specifics of the source and format of original data. All relevant parameters could be saved on this way and used later for processing (tracking of relevant events in the system, user behavior, usage patterns…). This will be useful for all higher blocks in architecture that should perform very complex algorithms on gathered data. These complex components in the system include:

Software agents, responsible for monitoring processes in the system based on the data from various sources

Data mining system (DMS) that performs various complex algorithms (based on neural networks, decision trees...) in order to predict requests to the system, input data, and hence response of the system. If analysis in this task shows that performing necessary algorithms

Deliverables **D2.1** (M9) – Report on HW built into the system **D2.2** (M9) – Report on Communication system built in the system **D2.3** (M9) – Report on SW built into the system

Work package number	3		Start date or starting event:						Beginning of M1	
Work package title	Adding intelligence to the WSN system									
Activity Type[12]	SUPP									
Participant id	1	2	3	7	8					Total
Participant short name	TMG	BGDUNI	FERRARA	SPACE	FE					
Person-months per participant:	15	20	10	5	20					70
Objectives Adding intelligence to the overall system. Adjusting the added intelligence to six application scenarios.										

Description of work

WP Leader: FE

T3.1 Definition of KEP procedures (TL: FE)

Decision making is added to the system through collection of all six types of AW (products, services, human resources, novel ideas, environment states, optimal actions) for specific six use cases, as defined in WP1. Business optimization parameters (CSP) and environment awareness parameters (EAP) from WP1 will be considered for the six use case scenario taking into account possible opposing and entropy connected forces. Knowledge extraction procedures (KEP) will be developed for this purpose by means of appropriate DB mechanisms, AWS, and system dynamics intended for each specific niche application.

Based on LMSE (Laboratory of Microsensor Structures and Electronics, Faculty of Electrical Engineering, University of Ljubljana) previous experiences in medical applications, a novel muscle contraction micro electro-mechanical system (MC-MEMS) sensor will be designed, developed, and fabricated for muscle's transversal change measurements. Preliminary test with temperature compensated silicon transducers assures sufficient sensitivity and dynamic response in such measurement. Combining MEMS structure with adequate read-out electronics enables not only adaptable accession to individual muscle behavior but also wireless data acquisition of measured results. As such, these novel MC-MEMS sensor could measure muscle behavior in real physiological conditions and sends results to allocated database, where further analysis is possible.

During muscle contraction, transverse part of muscle force will induce mechanical stress in mechanical part of detector (beam). Therefore, beam should be properly designed to assure both, adequate sensitivity of detector and appropriate tension to measured muscle. Silicon transducer will convert induced mechanical stress into an electrical signal. Due to temperature dependence of silicon transducer, output response will be temperature compensated on chip. Appropriate microcontroller will then convert transducers output signal into digital signal and assure data acquisition of measured muscle properties.

T3.2 Definition of CEA algorithms (TL: FE)

Data mining procedures will be refined using appropriate description logics, Bayes networks and reinforcement learning procedures for each specific use-case. Concept extraction algorithms approach (CEA) will be set for extracting automatic concept generation on the scenery at hand. Concepts will be further handled through their consistency with the QoL, QoS, and RoS restrictions.

T3.3 Definitions of RRG generators (TL: FE)

A modelling tool for extracted concepts will be developed that generates ranked recommendations for specific scenario and for each one of the six use cases. These business oriented ranked recommendation generators (RRG) are based on qualitative scenery modelling changing priorities of ranking of data and goal functions for each specific scenery and for each specific concept at hand. Because of the possibility of the NP optimization problem, an on-line expert based communication will be provided.

Deliverables **D3.1 (M9)** – Procedure details **D3.2 (M12)** – Algorithmic details **D3.3 (M12)** – Decision making details

Work package number	4		Start date or starting event:						Beginning of M10	
Work package title	Development of hardware, communication, and software platform, for the full blown system									
Activity Type[12]	SUPP									
Participant id	1	2	3	7	8	9				Total
Participant short name	TMG	BGDUNI	FERRARA	SPACE	FE	FRI				
Person-months per participant:	15	10	15	10	5	10				65

Objectives

Development of hardware, communication and software platform for the full blown system

Model and analyze system complexity in order to optimize solution to speed of response and required memory space

Generate system simulation cases and test simulation results:

Design, development and testing of a general distributed system architecture, based on the specification from WP3 that will be able to implement three main issues of the technology-enhanced system: flexibility, creativity and easy-of-use.

Identification and specification of required hardware components for building the communication infrastructure including all kind of actuators, sensors and personal interfaces.

Identification and specification of required software components for the managing of the low level input/output data or eventual acceleration (parallelization) of internal complex algorithms.

Design and development of a wide variety of software interfaces, preferably open-source if available, tailored to different users and requirements (e.g. students, older people, education, examination, etc.).

Design and development the covering high level software derived mostly by automatic means from the proposed system design.

Description of work

WP Leader: FERRARA

T4.1 Hardware and communication design (TL: FERRARA)

Select system platform according to specification from WP3. Architecture design.

Design hardware and communication facilities required from WP3 for specific purposes given in WP2. The design will be based on agent driven ad-hoc enterprise solutions. Special care will be given to the system hierarchy, middle layer correspondence and system security. The goal of this task is to prepare a system proposal for PoC solutions. Extensive exchange of WB and EU countries experts will take place. Students undertaking joint PhD studies agreed in WP2 will be included in the ITN.

A technology-enhanced creative system (TECS) requires a lot of computing capacity that can be implemented on existing networked computers. Cloud and Grid technologies in all their variants has been developed and proposed in recent years. They provide an efficient and efficient way, regarding financial and organizational effort, for the implementation of the proposed system using mostly the existing ICT infrastructure required. Cloud or Grid technologies are becoming standardized solutions for distributed computing on a larger geographically areas. The specific goal of this WP is to build an ad-hoc computing network, inspired by Grid/Cloud technologies, which will support the computational and communication requirements of TECS.

The proposed system will be designed mostly from already existing commuters, originally installed for some other general tasks, like teaching, training, research, entertainment, etc., but with unexploited resources available for the requirements of TECS. These ICT resources are generally not located in the same place and can have very heterogeneous resources in terms of processor type, storage capacity, available network bandwidth, operating system type, etc. Also, their availability can change with time, depending on their primary use. Communication between nodes is usually performed over public networks and must be made secure. Broad public usage of computational and storage resources would also require future charging policy which will be foreseen for the future implementation.

By increasing the number of cooperating sites, the communication and computation load also increase. There are some limits posed in such systems, determined by the hardware parameters like, storage capacity, computing performance, communication speed etc. The latter also depends on the characteristic communication patterns of the algorithm, in particular, the amount of data to be transferred and the frequency of communication needed during calculation. We will identify these limits and made estimation and measurements that will support the theoretical findings.

Available interconnection technologies will be used for communication infrastructure. Some amount of hardware design is envisaged in wireless communication among some low level system components (sensors, personal terminals, etc.). Potential custom hardware development is expected also on the low level communication between sensors, RFIDs, smart cards, etc., which are today not matured yet and are still subject to the standardization.

T4.2 Software design (TL: FERRARA) – The goal of this task is to ensure that appropriate software platform meets the requirements of the project requirements as specified in WP2 and WP3. System architecture design. Software design will take place on the basis of complex analyses of the requirement specification fulfilment. It will be implemented on the relevant abstraction level in order to enable one-to-one transposition into PoC solutions taking into account the developed hardware and communication facilities and installations at WBC centers. System simulation will be developed, system simulation cases will be tested, and simulation results presented and analyzed.

Deliverables **D4.1** (M12) – Schematics **D4.2** (M18) – Documentation, in-block and in-line

Work package number	5	Start date or starting event:	Beginning of M10

Work package title	Development of PoC, as a subset system									
Activity Type[12]	SUPP									
Participant id	1	2	3	7						Total
Participant short name	TMG	BGDUNI	FERRARA	SPACE						
Person-months per participant:	15	10	5	5						35

Objectives

Requirement engineering for a specific case in measurement automation

Development of case-scenarios and building the analysis and behavior model

Conducting component level design

Performing CMMI design

Performing web and field-devices design

Testing: at local level, web application testing, field-device application testing, security testing

Documentation issue

Development of prototype system according to the specified architecture, hardware and software components targeted for the specified field trials defined in WP6

Specification of a system evaluation plan including test case specification to validate all design and performance of all designed components and the system as a whole. Particular attention will be given to evaluation and validation of key innovations. The goal is to assess how well the prototype meets the use cases and requirements stated in WP1.

Evaluation of the system as a whole in order to prepare for the filed trials specified in WP6.

Description of work (WP leader: BGDUNI)

The work in this work package is focused on providing system prototype with reduced functionality set when compared to the full system design outlined in WP4. However, the resulting system prototype should cover the specified and selected business scenarios and use-cases outlined in WP6. Furthermore, the work package will include the system testing and evaluation in order to produce next generation of the system.

T5.1 Architecture and design in CMMI and system schemes of the subset to implement (TL: FERRARA) – A specific use-case will be selected and elaborated in all application details in order to get the appropriate requirement specification. For this use case the development of case-scenarios will be performed and the analysis model will be built. A composite of scenarios will generate the system behavior model as the basis for PoC design engineering. Software architecture will be designed and refined. The component level design will be performed. CMMI design will be incorporated and web and application devices extensions added to the design.

Taking into account outcome of tasks T4.1 and T4.2 where the overall system design is defined, this task is focused in providing detailed architecture and design of the reduced feature-set system inline with the field trials outlined and defined in WP6.

Issues of importance:

Logical design. Architecture and logical design of HW module will be made according to chosen components. Some components can be replaced with new components in this stage.

Pin to pin connection diagram. Design of printed circuit board. Circuit assembly and basic functionality test. Case design and module assembly.

T5.2 Programming of the applications, Version 1 (TL: FERRARA) – The main goal of this task is to conduct exact programming of the PoC applications taking into account the design of conventional components, web and application devices (WSN, mobile extensions etc), security aspects and the overall system requirements such as DB and intelligent system behavior. This task is focused on development of all of the software modules to be used within the prototype system, version 1

T5.3 Testing Version 1, and generation of Version 2 (TL: FERRARA) – Testing strategy will be proposed, and test validation metrics installed. Testing tactics will be incorporated in coordination with tasks T5.1 and T5.2. The emphasis will be on testing for real-time systems. Testing patterns will be generated and approved. Testing for web application, CMMI, field application devices and security will be added and performed. Define the test cases for the unit and system tests in order to verify whether the system meets the performance and feature requirements outlined in WP2

Deliverables

D5.1 (M12) – CMMI and system schemes

D5.2 (M18) – Documented code

D5.3 (M24) – Documented testing procedures and final code documented

Work package number	6	Start date or starting event:	Beginning of M25
Work package title	Testing of PoC in real-life scenarios		
Activity Type[12]	SUPP		

Participant id	1	2	3	5	6	7	10			Total
Participant short name	TMG	BGDUNI	FERRARA	ORTO	KOPUNI	SPACE	BSC			
Person-months per participant:	20	20	15	30	15	5	15			120

Objectives

Define testing strategy of PoC in real-life scenarios by reduction of system functionalities

Define expected QoL and QoS from the installed PoC research areas of common interest to project participants for the future research

Implement PoC installation on time and without functional bugs

Specification for the execution of the Field Trials in each of the organizations taking into account specifics about each of the organization and each of the country. This plan will define procedures and test cases for the technical assessment of the system in a real environment and with the end users. In addition, the specification will define the procedures for involvement of the end users including the personal data privacy and protection measures.

Execution of the filed trials

Evaluation of field trials results in order to compare the end-user experiences, system performances under different conditions, potential benefit to the business

Based on the outcome of the trials, making recommendation about the potential commercial product(s) that will be directly benefiting post-project exploitation phase

Description of work

WP Leader: ORTO

T6.1 Testing in Slovenia (TL: KOPUNI) – Selection of the appropriate hospital for testing purposes in Slovenia. Installation of the medical equipment – WSN, mobile devices, field actuators. Installation of the web connection facilities. Installation of the PoC at the site. Organizing and performing PoC testing procedures. Testing of exceptions, obstructions, and entropy. Report on testing according to metrics for testing and metrics for maintenance. Include QoL and QoS parameter testing. The findings in the report will be used further and will have impact on the content of the future PfM requirement issues. The report will also serve to widen the cooperation of the pool of researchers who are in the areas listed above.

This WP also includes tests definition and planning. Based on the selected scenarios and requirements, the trial applications and execution plan will be specified for each of the organization taking into account its location, business model, targeted application, structure of end users etc. If the proposed field trial raises ethical issues, for example privacy concerns, an ethical review will be undertaken. Furthermore, a comparison metric will be defined in order to compare the test results originating from different test sites. The aim of the metric is to specify the parameters that will be measured during the tests such as end user experience, system price, system performance, final product cost-reduction when using the system etc.

T6.2 Testing PoC in SLO conditions (TL:KOPUNI)

Organizing and performing test at the KOPUNI in Slovenia. Testing of exceptions, obstructions, and entropy. Report on testing according to metrics for testing and metrics for maintenance CMMI testing. Includes QoL and QoS parameter testing. The findings in the report will be used further and will have impact on the content of the future PfM requirement issues. The report will also serve to widen the cooperation of the pool of researchers who are in the areas listed above.

T6.3 Testing in Serbia (TL: ORTO) – Selection of the appropriate farm for testing purposes in Serbia. Installation of the field equipment – WSN, mobile devices, field actuators. Installation of the web connection facilities. Installation of the PoC at the site. Organizing and performing PoC testing procedures. Testing of exceptions, obstructions and entropy. Report on testing according to metrics for testing and metrics for maintenance. Include QoL and QoS parameter testing.

T6.4 Comparison and suggestions of product for market (TL: ORTO) – During the testing phase on both locations a number of remarks and hints will be generated. These, together with concrete testing results will be the basis for comparison evaluation of the both PoC installation behavior in real-life conditions. Based on these and PoC features, its reduction factor from the system platform and on general system requirements the set of suggestions for PfM will be generated as the basis for spin-off activities of SMS's both in WB countries and in EU countries. The new framework may also include new geographic regions and potential collaboration with research groups in these regions.

Once all the tests have been executed according to the specification produced in T6.1, the results will be compared using the metric defined in the same task. The aim is to quantify the comparison results and deduce which type of the system (or which system's features) are better suited for the market.

Deliverables
D6.1 (M34) – Report on testing results in Slovenia
D6.2 (M34) – Report on testing results in Slovenia
D6.3 (M34) – Report on testing results in Serbia
D6.4 (M35) – Proposal for product development for mass market

Work package number	7	Start date or starting event:			Beginning of M1					
Work package title	Informing the scientific and technical environment									
Activity Type[12]	SUPP									
Participant id	1	2	3	4	5	7				Total
Participant short name	TMG	BGDUNI	FERRARA	MEDIA	ORTO	SPACE				
Person-months per participant:	10	20	15	10	10	5				70

Objectives
To do constantly a public dissemination about this project
To do periodically internal workshops and scientific symposia
To help generate spin-off companies interested in making the market product related to this system
To prepare market for acquisition of this system
To define strategic research areas of common interest to project participants for the future research

Description of work

WP Leader: MEDIA

T7.1 Kick-off meeting (TL: MEDIA) – It is anticipated that DiaMus systems will be widely applied in the coming years, with research challenges shifted towards scalable adaptive pervasive systems and incorporating heterogeneous systems which may include robots, actuators, mobile sensors, and human teams both at the consumers and medical producers side. Based on the project results and experience and taking into account the state of the art in medical monitoring-automation research in 2010 and general research interest of each partner, a set of research challenges of common interest will be identified. These challenges will be summarized in a report. The findings in the report will be used to further advance the ties established up to this point as an input for planning of new projects and new collaborations. They will have impact on the content of the future workshops, summer schools, graduate courses, joint supervision, and joint research activities. The report will also serve to widen the cooperation of the pool of researchers who are in the areas listed above.

T7.2 The first annual workshop (partners only) (TL: MEDIA) – During the project a number of short and long term collaborative activities will take place on bilateral and multilateral basis (research visits, joint PhD studies, joint FP7 proposals). Taking into account the ongoing actions and the output from T7.1 identifying common research interests of different partners, bilateral or multilateral agreements will be put in place. The agreements will gather all existing and new collaboration mechanisms under one umbrella agreement. Procedures, policies and ways of working between different parties in the agreement will be formalized to ensure smooth continuation of partnership established in the project. The new framework may also include new geographic regions and potential collaboration with research groups in other Balkan countries.

T7.3 The first annual symposium (partners and beyond) (TL: MEDIA) – During the project a number of short and long term collaborative activities will take place on bilateral and multilateral basis (research visits, joint PhD studies, joint FP7 proposals). Taking into account the ongoing actions and the output from T7.1 identifying common research interests of different partners, bilateral or multilateral agreements will be put in place. The agreements will gather all existing and new collaboration mechanisms under one umbrella agreement. Procedures, policies and ways of working between different parties in the agreement will be formalized to ensure smooth continuation of partnership established in the project. Each agreement will leverage any existing national, regional or international initiatives, such as 'Networking with Southeast Europe' (**www.see-era.net**) to enhance the new collaboration framework and facilitate better and more efficient collaboration. The new framework may also include new geographic regions and potential collaboration with research groups in other Balkan countries.

T7.4 The second annual workshop (TL: BGDUNI**)** – Reporting on the progress.

T7.5 The second annual symposium (TL: BGDUNI) – Continuing to bring together the elite of the field.

T7.6 The third annual workshop (TL: TMG) –Final reporting on the project.

T7.7 The third annual symposium with closing discussion (TL: TMG) –Final bringing together the elite of the field.

Deliverables
D7.1 (M1) – Set of Rs by partners on planned activities
D7.2 (M6) – Number of papers (Ps) written for the first annual workshop
D7.3 (M12) – Number of papers (Ps) written for the first annual symposium
D7.4 (M18) – Number of papers (Ps) written for the second annual workshop
D7.5 (M24) – Number of papers (Ps) written for the second annual symposium
D7.6 (M30) – Number of papers (Ps) written for the third annual workshop
D7.7 (M36) – Number of papers (Ps) written for the third annual symposium

Work package number	8	Start date or starting event:				Beginning of M1				
Work package title	Impact on the environment									
Activity Type[12]	SUPP									
Participant id	1	2	3	4	5	7				Total
Participant short name	TMG	BGDUNI	FERRARA	MEDIA	ORTO	SPACE				
Person-months per participant:	10	20	10	15	10	5				70

Objectives
Although not typical, this project likes to have different work packages to organize and monitor effects of technical and scientific meetings, on one hand, and public dissemination with search for investors, on the other hand.

Description of work

WP Leader: SPACE

T8.1 Informing the environment via media (TL: SPACE) – It is anticipated that diagnostic automation solutions will be widely applied in the coming years, with research challenges shifted towards farm-scalable adaptive systems and incorporating wide spectrum of sensing and actuator devices and farm equipment. Based on the project results and experience and taking into account the state of the art in agro automation research and general research interest of each partner, a set of research challenges of public interest will be identified. These challenges will be summarized in a report.

Important: To develop two kinds of event series: Open Research Days and Open Innovation Days. They will be focused on the cross-fertilization between scientific results of the project and the potential business interest of entrepreneurs, investors to achieve a wide dissemination through in-house talks, brainstorming meetings, seminars, summer schools and special sessions in EU.

T8.2 Search for investors to turn PoC into a market product (TL: TMG) –Promotional activities - Diverse selected technology focused media events, trade fairs, TV and radio shows and newspaper supplements will be used to promote the project and draw attention to its benefits and potential applications of its relevant technology.

Important: Set up of a mechanism for the partners to collate market intelligence relevant to DiaMus technology. Events and trends analysis, members of one section of the Industry (e.g. Wireless Sensor Networks) will be able to catch up on events in other fields that affect their business indirectly, but which they would not have had time to investigate. To build upon the market awareness data gathered in Market Analysis and apply it to construct a coherent approach to the exploitation of project results. To create a plan based on a comprehensive picture of the future trends and emerging market sectors. It will be the first time that such an integrated picture has been created for Wireless Sensor Networks in several domains. Better prediction of the market development will allow in turn the manufacturer to produce a concerted market strategy for 'rollout'. In addition to looking at commercial exploitation by the partners, we will consider possible exploitation by further RTD.

T8.3 Organization and monitoring of talks and business plans for PfM investors (TL:BGDUNI)- Organization and monitoring of impact on scientific and technical environment. Organizing meetings with SMS's, producing business plans and animating deployment of main project results and ideas.

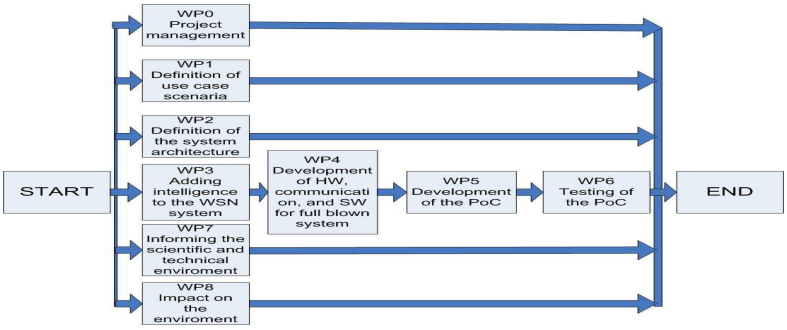
T8.4 Supervision of impact on the social environment (TL: TMG)- Supervision of impact of project result on the social environment.

Deliverables **D8.1** (M36) – List of public appearances for dissemination purposes, and content there-offs D8.2 (M36) - List of investor contact and presentations made D8.3 (M36) - List of brainstorming meetings, and contents there-offs. **D8.4** (M36) – List of in-house talks and brainstorming meetings, and contents there-offs

1.3.3.e. Summary effort table

Men/Month (MM)	WP0	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	ΣMM
TMG	15	15	15	15	15	15	20	10	10	130
BGDUNI	0	20	30	20	10	10	20	20	20	150
FERRARA	5	5	30	10	15	5	15	15	10	110
MEDIA	0	0	0	0	0	0	0	10	15	25
ORTO	0	0	0	0	0	0	30	10	10	50
KOPUNI	0	0	0	0	0	0	15	0	0	15
SPACE	5	5	5	5	10	5	5	5	5	50
FE	0	0	5	20	5	0	0	0	0	30
FRI	0	5	0	0	10	0	0	0	0	15
BSC	10	0	0	0	0	0	15	0	0	25
ΣMM	35	50	85	70	65	35	120	70	70	600

1.3.4. A graphical presentation of the components showing their interdependencies (Pert diagram or similar)



1.3.5. Describe any significant risks, and associated contingency plans

The research project is continuously monitored by project management and thoroughly evaluated twice per year at special risk analysis meetings. All identified risks will be ranked in terms of a potential impact on the project and probability of a risk actually taking place (impact multiplied by probability). The project will focus on 3 top risks. Specific measures to counteract the risks will be defined for each risk and action point assigned to people responsible for following them up. The progress will be followed up regularly until the risk is neutralized. Between the risk analysis meetings, it will be an ongoing responsibility of the project management to identify potential risks. This ongoing process will make sure that the project stays in line with the initial and possibly evolving planning, and that the quality of the work, the deliverables and the results stay at the highest level for wide acceptance.

At the first project meeting a risk analysis session will be held to identify a list of major potential obstacles. Following the process explained above, an action plan will be defined and followed up at subsequent project meetings. Potential 3 top risks envisaged at this moment are:

Completing in time and with appropriate quality all the ambitious tasks specified in this proposal.

Ensuring that all teams, from different geographical areas and different S&T backgrounds do communicate with each other in an effective manner.

2 Implementation

2.1 Management structure and procedures

Describe the organizational structure and decision-making mechanisms of the project. Show how they are matched to the complexity and scale of the project.

The project involves several partners from different countries and intends to provide support for multiple activities involving a number of researchers and students from different organizations. Therefore, coordination and management of the project are of paramount importance. The basic project management approach for the project is to have a scientific coordinator focus on the technology and to have an administrative coordinator handle the overall operational and day-to-day business. A clearly defined project management structure will be set up, including precise management processes and decision rules. This will ensure that the project meets its objectives and delivers the results in time and with high quality, using the following project management structure (Figure 6):

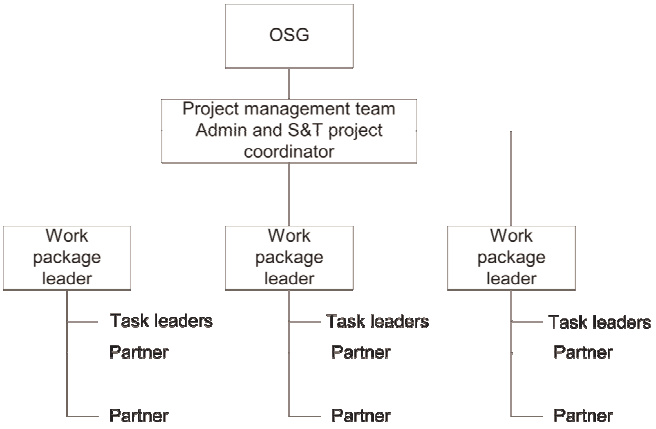


Figure 6: Management Structure

Precise milestones and delivery dates as well as the content of the deliverables are defined in a detailed project plan. Project control will be established, supported by communications tools and a central communications platform. A self-check mechanism for the work package leaders and the researchers/developers will provide an early warning system to identify deviations from the work plan and make it possible to establish contingency or recovery plans.

A project management team comprising a senior project manager and a senior researcher as the scientific coordinator will lead the project, making use of state-of-the-art project management techniques. The objective of the day-to-day management is to keep the project always closely aligned with the project plan, reduce the risks associated with project activities and provide support to all partners. Individual effort for administration of the project should stay at a minimum, including the number of meetings necessary to control the project.

The project operational steering board will be established to monitor the progress and direction of the project. Each partner will have one board member.

Project operational steering board

The project operational steering board (OSG) will have the following responsibilities:

Approval of the overall project objectives, targets and general directions

Evaluation of approaches and progress of the project

Approval of progress reports

Approval of significant project changes to be proposed to the Commission

The board will meet at the project kick-off meeting, for significant milestones and when requested by project manager.

Project manager

The Project Manager (PM) will have the following responsibilities:

Overall co-ordination of the project execution and inter-partner co-operation

Maintenance of project plan

Risk analysis and mitigation

Interfacing to the European Commission, liaison with all partners and stakeholders

Preparation and assessment of progress reports and deliverables

Financial distribution of the payments to the partners

Chairing the project meetings

Public relations and dissemination of project results through professional channels

Installing and running the project web site. All partners will regularly contribute their inputs.

S&T Manager

The S&T manager will have the overall responsibility for the scientific and technical direction of the project and will report to the project manager. The S&T manager will maintain a continuous liaison with all work-package leaders exchanging and evaluating meaningfully and efficiently information on project work performed and to be performed next. The duties of the S&T manager will be:

Coordination of the scientific and technical activities of the project and driving the project's S&T strategy

Take the necessary predefined actions in order to avoid any technical risk or resolve any conflict. Minimize risk and update the risk factors if it is needed.

Regular communications with the PM.

Co-ordination knowledge management and other innovation-related activities at the consortium level.

Participation and presentations at events and/or exhibits (IST or other relevant EC events).

The Project Manager and S&T manager will have continuous contact with the project team by email, phone or through face to face meetings. A management mailing lists shall be established for communication of all project management information. The Project Manager and S&T manager will be supported by dedicated offices of the home institutions, on legal issues and personnel issues, as necessary, with appropriate input from financial and administration staff in partner organizations.

Work package leaders

These leaders will comprise the S&T committee. The S&T committee will meet every quarter. Additional ad-hoc meetings will be held on specific work packages whenever the Technical Manager or the Project Manager find that such a meeting is required. Meeting locations will be specified at the time of the kick-off meeting. The goal will be to have these meetings together with some of the other project events to minimize the cost.

Each work package will have a designated leader from the organization managing the task. Leader will have the following responsibilities:

To present monthly progress reports to the S&T Manager for the work performed and to be performed next.

To propose the methodology for carrying out the work in the corresponding WP.

To communicate the technical work with the Task Leaders.

To perform full reviews of the deliverables in the corresponding WP.

To submit the final Deliverables to the Project Manager.

To give oral presentations at Technical Committee or Review Meetings.

To propose to the S&T Manager dissemination activities, such as presentations and/or exhibits for any IST or other relevant EC event.

In each WP, Task Leaders (TL) will be appointed with the following responsibilities:

Compile the Table of Contents of the corresponding deliverables, collect contributions from participating partners and edit the deliverables.

Allocate work to the involved partners in the specific task.

Submit the deliverable to the WP leader for review and approval.

All Partners

All partners will have the following responsibilities:

To prepare individual management reports and submit them to the PM.

Management of their team and the good cooperation with the other teams in the consortium by regular internal meetings and well-established communication channels.

To follow closely the project plan and respect project's defined procedures.

To fulfil the required financial procedures (e.g., audit certificates).

Decision making process including conflict resolution

The project operational steering board (OSG) shall approve all major decisions that have to be executed by the Project Management. The OSG is chaired by an OSG member elected at the first OSG meeting. All partners have one vote in the OSG. The project OSG obligations are to:

- Review the progress of the project as a whole;
- Approve and accept the work plan and necessary modifications that need to be proposed to the project officer for approval;
- Approve IPR-related issues such as publications, as defined in the consortium agreement;
- Approve any change in the consortium agreement and recommend to the management of the partners acceptance of changes;
- Approve and accept deliverables of the project of a technical or reporting nature;
- Decide on possible conflict resolution proposals by the project management or partners;

The objective for the decisions making process is to achieve consensus in all relevant issues. The regulatory regime for the formal voting will be specified and agreed in the consortium agreement part on organizational matters. The escalation process in case of conflict consists of steps within the project and at external instances as specified in the consortium agreement:

In general the project management shall make sure by its also mediation nature that conflicts are prevented:

- In case of conflicts the project management shall function as a mediator and help to find a mutual settlement
- If that can not be achieved a proposal will be made to the OSG to help to settle a conflict within the project
- According to the consortium agreement the next steps of conflict resolution will be arbitration and finally a court specified in the appropriate section.

Communications

The main communication channels used in the project will be email, web site and phone. The project's web site with accompanying tools will be the central communication point that will provide immediate on-line information for project members at any time. Meeting agendas, individual to-do lists and other important project information will be accessible via the Internet. File archive for project files containing relevant project documentation and supporting materials will be also available. Document versioning will be used for all working documents.

Project Evaluation and Quality Control

Continuous project evaluation will take place to verify the quality of the deliverables, working documents and research results, measured against the project vision, objectives and quality requirements of the European Commission. The project monitoring and control takes place on various levels:

Project Level: The progress of the project versus the implementation plan will be continuously monitored and is subject of regular communication, working meetings and OSG meetings, with a special partner dedicated to this issue. The work package leaders will carry out detailed work planning and controlling of their respective work packages.

Result Compliance with objectives: It is essential that the individual work results support the overall and individual project objectives.

Deliverable Schedule: The work in the individual work packages will yield not only technical results but at the same time formal deliverables that are committed in this description of work. A focus of the project management will be to assure the work on the deliverables starts at an appropriate time before the Deliverables are due.

Deliverable Quality: Before deliverables are submitted to the commission (and those that are public to the public website) they go through a stringent technical and editorial review process:

The partner responsible for the deliverable collects all technical input from those involved in the work package and prepares a first technical draft. The draft is circulated for comments and suggestions to the consortium and the pre-final draft deliverable is submitted to project management for editing. Final editing is done to make sure that not only readability and content are high quality but that formalities are taken care of appropriately. In case a deliverable contains a number of complex issues that are important to be understood by the target audience a peer review will be used to make sure that the content of the deliverable is appropriately described. The final step is a consortium approval.A last round of changes might be necessary before the deliverable is submitted to the European Commission Project Officer and the Reviewers.

Plan for using and disseminating knowledge

Knowledge generation and dissemination are the core activities of the project. There are two aspects of this activity: internal and external. Internal dissemination is organized at workshops and working meetings. External dissemination is oriented to two goals: Informing the wider community and producing a market product.

The main tools of the earlier activity are scientific papers, presentations, lectures and demos in journals, at conferences, exhibitions and different media channels (web, TV, newspapers). Selected project deliverables will also be available at the project web site. It is an aim of the project to make most project deliverables public. The web site will contain a private area open to all project team members as well where project information and documents including minutes, plans, results and background information can be easily accessed.

The main goal of the later is to create a business plan for activities leading to a market product and to search for potential investors. A special partner is incorporated to realize this mission.

IPR management

If in the course of transfer of knowledge or other project activities, which are the core activity of the project, discussions of existing and potential intellectual property take place the management of intellectual property will follow the general principles set out in the IPR rules for Framework 7 and will be defined in detail in the Consortium agreement.

2.2 Individual participants

The list of individual participants is given in Appendix 5.

TMG, Ljubljana, Slovenia

The company TMG-BMC d.o.o. is a small Slovene company which- on the basis of its own knowledge- develops and markets the systems and services for the optimization of the

training process of top sportspeople and the optimization of the rehabilitation processes in physiotherapy. The basis of the products and services of the company is the method called tensiomyography (TMG), which has been developed with its own knowledge and for which the company has acquired patent rights. Muscle diagnostics with the TMG method ensures unique information about the state and development of a muscle, which is the basis for a number of improvements in the fitness and rehabilitation processes. The method, which was originally designed for usage in medicine, redirected its focus to top sports, where there were fewer obstacles for its establishment.

TMG-BMC d.o.o. has extended knowledge about biomechanical human properties. Our typical costumers are European professional sport clubs (FC Barcelona, FC Villarreal, FC Fiorentina, FC Dinamo Kiev , FC Udinese). We offer complete service packages for injury prevention and speed development. TMG-BMC company has experiences, knowledge and skills in diagnostic systems development, covering:

- Functional materials (nano technologies)
- Accelerometers
- Smart sensors (MEMS)
- Charging modules
- Communication modules
- Microprocessors
- Digital signal processing
- Software developing
- Biomechanics
- New technology applying in practice for purpose of movement optimization, rehabilitation, speed development, injury prevention …

Patents:

- EU patent Application No./Patent No. : 02707391.5-2305
- Slovenian patent, Patent No. : 20846
- Irish patent , Patent No :1424938
- UK patent , Patent No :GB1424938
- Dutch patent , Patent No :NL1424938

We have successfully finished two government founding project: Development of tensiomyographic diagnostic system for muscle diagnostic and diagnostic system for measuring contractile muscle properties on people with head injury. Both projects have resulted as patents follow up sales.

In TMG-BMC Ltd is active research organization registered under number 2442 in Slovenian research agency register. Leader of research organization is Dr. Boštjan Šimunic

Boštjan Šimunić, PhD, was born on 28 December, 1974, in Novo mesto, Slovenia. After finishing primary school at Dolenjske Toplice, he attended the Secondary School of Electrical Engineering of Novo mesto, and was granted the state's scholarship for talented pupils. He continued his studies at the Ljubljana Faculty of Computer and Information Science (computer logic and systems), from which he graduated with honours in 1999. In the second year of his postgraduate studies, he started working as a junior researcher at the Laboratory for Biomedical Visualization and Muscle Biomechanics. In 2001, he received his Master's degree for his thesis The Analysis of the Variability of Skeletal Muscle Response to Electrical Stimulation (Faculty of Electrical Engineering). In 2003, he concluded his doctoral study with the doctoral thesis Modelling of Longitudinal Shortening and Transverse Deformation of Skeletal Muscles to Electrical Stimulation (tutorship Prof. Dr. Vojko Valenčič). After receiving PhD, he was employed by the TMG-BMC Ltd, which deals with medical diagnostics and research on skeletal muscles. Apart from working in TMG-BMC Company he also works as a professor at the University of Primorska, Faculty for Education.

Bostjan works in a scientific fields of (and his publications comes from fields of) Electronics, Intensive mathematical methods, Kinesiology and Physiology. Bostjan was involved in several technological and scientific projects:

- Head of the Technological project: The development of the commercial system for detection of skeletal muscle contractile properties (co-financed by Ministry of Economics Republic of Slovenia, 2002-2003: 65540 EUR);
- Researcher in the Technological project: Placement of new project on new specific markets of European Union (co-financed by the Ministry of Economics Republic of Slovenia, 2003-2004: XXXXX EUR).
- Researcher in the Applicative project: Measuring systems for assessment of skeletal muscle contractile properties of healthy subjects and in some muscle pathological conditions (co-financed by the TMG-BMC Ltd and Ministry of Higher Education and Technology, 2004-2007: 37556 EUR).
- Researcher in the Applicative project: Role of Biomechanical Properties of Skeletal Muscles in Child Motor Development (co-financed by the Ministry of Higher education and Technology, 2001-2004: 112669 EUR).
- Researcher in the Basic project: Monitoring of changes in biomechanical characteristics of skeletal muscles in early childhood and adolescence (co-financed by the Ministry of Higher education and Technology, 2004-2007: 75125 EUR).
- Researcher in the Applicative project: Altitude Acclimatization (co-financed by the Slovenian Olympic Committee and Ministry of Defence Republic of Slovenia, 2007-2008, 25433 EUR).
- Head of the part of the applicative project: Soldier Protective Systems – The Heat study (co-financed by the Ministry of Defence Republic of Slovenia, 2006-2008, 53234 EUR).
- Head of the part of the applicative project: Defense Segments Modelling with Markov Chains: Preparation of Staring Points for Recruiting and Retention of Human

Resources in Slovenian Armed Forces (co-financed by the Ministry of Defense Republic of Slovenia, 2006-2008, 92435 EUR).

- Head of the target research project: A Child in the Midst of the Effects of Sedentary Lifestyle – Motor Abilities, Physical Characteristics and Health Status of Slovenian Children (co-financed by the Ministry of Education and Sport, 2007-2009, 60000 EUR).
- Co-Head of the international research programme: The effect of weightlessness on human organism – bed rest studies (co-financed by European Space Agency, 2006-2009, 600000 EUR)
- Researcher in 5th Framework Programme project (WebSET – Web set of Education tools) (co-financed by European union, 2000-2001, 50000 EUR).

In 2000, Boštjan Šimunič was bestowed the Student Prešeren Award for his graduate thesis Measurement and Analysis of Biomechanical Properties of Skeletal Muscles. In 2001, he received the Krka Fund Award, as well as the Rok Petrovič Fund Award for special achievements in the fields of academic studies and sport. In 2003, he was given another Krka Fund Award after having presented the findings of his doctoral thesis. Boštjan regularly publishes his findings in the international journals. Boštjan Šimunić is also a successful athlete; he is a national champion, record holder and Olympic contender in Athens 2008 in triple jump.

Srdan Đjordjevic has graduated from Biology at University of Ljubljana in 1987. He is also active as professional athletic coach from 1987. In this time he coached more than 30 athletes that participated on Olympic games. He is very active to combine R&D with practical- Srdjan has published over 40 scientific publications as author or co-author in sports, pre-clinical pharmacology biomechanics and applied physiology journals, posters or oral presentation at international scientific congresses.

Jure Jemec is general manager of TMG-BMC company. 2005, Jure graduated from Hardware systems on University for computer and information science in Ljubljana . He is finishing his MBA study on Economic faculty in Ljubljana . His daily activities in the company are project leading and controlling.

Faculty of Electrical Engineering, University of Belgrade, Serbia

University of Belgrade is a leading university in the area, and its School of Electrical Engineering enjoys a strong world-wide reputation. Currently there are 3809 undergraduate students and approximately 1000 graduate students at this school. School consists of ten departments including Telecommunications, Computer Engineering and Computer Science, Power Systems, Microelectronics and Physics, etc. Computer Engineering and Computer Science department is one of the largest with 830 students. Internet and telecommunication services research are the core activity of the CECS department for several years. The CECS have been involved in a number of national and international projects in these areas and

gained significant experience applicable to the activities in the Prosense project. The full list of projects of the University of Belgrade is available on request.

Prof. Veljko Milutinovic is a Fellow of the IEEE - recognition awarded for his introduction of the vertical migration computer architecture, which was used as the basis for his efforts to create (for DARPA, in 80s) a 200MHz microprocessor (about a decade before all major commercial vendors). Starting with 1990 he is on the faculty of the University of Belgrade. From 1982 till 1990 he was on the faculty of Purdue University, USA. Now, his major research is in the field of extraction of knowledge from the Internet, using Data Mining and Semantic Web, ad-hoc networks, neural networks, and P2P networks. He is also involved in a number of projects, both in the EU and US. All these projects are described in about 50 IEEE journal papers and 50 papers in other journals or book chapters, and in numerous conference publications. Prof. Milutinovic presented over 300 invited talks at all major universities in the World (MIT, Berkeley, Stanford, ...), in both computer engineering and business administration (Dartmouth, ...), on all 5 continents. He taught regular grad courses at various universities in the World, in 7 different languages (Serbian, English, German, Spanish, Italian, Russian, and Polish), and gave short invited lectures in 3 more (Swedish, French, and Czech). Professor Milutinovic published over 20 books with major USA publishers: Prentice-Hall, Wiley, Kluwer, North-Holland, McGraw-Hill, IEEE CS Press, ACM Press, etc. One of them was the best seller of all times for its publisher (IEEE CS PRESS), and for seven of them Forewords were written by Nobel Laureates. He was the General Chair or a Program Committee Member for several IEEE and other conferences. For four different IEEE Journals, he was Guest Editor or Co-Guest Editor.

His other activities include: research and development in computer engineering and web engineering. Its major successes include cooperation with some of the World leading companies, mostly in the USA: NCR, AT+T, Dow Jones, Wall Street Journal, etc… This partner will be responsible for administration, for system design, and for the development of the basic software (operating system).

Nenad Korolija has graduated in October 2002 at School of Electrical Engineering, University of Belgrade. He is currently working as a computer architecture programmer. Recent projects include P2P project “Swan” for Panthesis Inc. (Boeing spin-off) and e-business infrastructure for Dow Jones, NJ, USA.

Sasa Stojanovic has graduated in May 2006 at School of Electrical Engineering, University of Belgrade. He is currently working as a programmer in semantic web, internet and data mining areas. He is a PhD student. His Research interests include Computer architecture, VLSI design, Microprocessor systems.

Darko Jovic and Zoran Babovic have been working with Prof. Milutinovic for almost seven years at Belgrade University, School of Electrical Engineering. After graduation, they started as researchers on projects in cooperation with IPSI Fraunhofer Institute, Germany in 2003. Several projects were done in the areas of P2P networks and multimedia. Later on they spent a year (2004) as lead researchers in the area of storage technology and automated storage

management using scalable file systems, sponsored by StorageTek Company, USA (now acquired by Sun Microsystems). Recently, they were co-leaders in projects related to a real-time publishing system done for GTECH, UK, and maintaining consistency of the cached content in the dynamical environment of the Wall Street Journal Website, Dow Jones, NJ, USA. Their areas of interests are P2P networks, communication and consistency in the dynamical environment.

Bojan Furlan graduated in May 2006 and is currently working as a teaching assistant on a number knowledge engineering courses.

The group of Prof. Milutinovic also includes about 40 graduate students working on a number of on-going projects, and available to help on this one, too.

Consorzio Ferrara Ricerche, Italy

Consorzio Ferrara Ricerche (FERRARA), or Ferrara Research Association, is a non-profit organisation that pursues specific research objectives (including health, the environment, biotechnology, technological innovation, training, etc.), in collaboration with a number of Italian Universities. In the past decade, FERRARA managed around 1000 research contracts with public and private subjects. It has participated in many EU-funded activities (including FP5, FP6 and FP7 IST/ICT projects), both as partner and as coordinator, and has managed resources within the European Regional Development Fund, Objective 2.

The research work within the proposed project will be performed by Prof. Michele Zorzi and his wireless communications and networking research group. The researchers involved have strong expertise in the areas of ad hoc and wireless networking, ad hoc routing, sensor networks, resource management, multi-radio/multi-channel schemes, energy efficient protocols, cross-layer issues, adaptive and reconfigurable protocols, and implementation issues. FERRARA's key participants have been involved in a number of EU-funded efforts, including EYES, Embedded WiSeNTs, e-SENSE, Ambient Networks (Phases 1 and 2), NEWCOM and NEWCOM++, SENSEI, ARAGORN, and in several national and industrial projects as well.

FERRARA's main technical contribution in the project will be on the wireless sensor network infrastructure, and will focus on architecture definition and hardware/software component analysis, design of communications and networking schemes, as well as their proof-of-concept implementation and testing.

Michele Zorzi is Professor of Telecommunications at the School of Engineering of the University of Padova, where he has been since 2003. He received the Laurea Degree and the Ph.D. in Electrical Engineering from the University of Padova, Italy, in 1990 and 1994, respectively. Before his current appointment, he was a faculty member at the Politecnico di Milano (1993-1996), a Research Scientist at the Center for Wireless Communications, University of California at San Diego (1995-1998), and a Professor at the University of Ferrara (1998-2003). He is very active in the field of wireless communications, has published more than 350 papers in refereed journals and international conferences, and is a Fellow of the IEEE. He has been editor and guest editor for IEEE journals and magazines, and has been involved in organizing international conferences. He served as the Editor-in-Chief for the

IEEE Wireless Communications Magazine in 2003-2005, and is currently the Editor-in-Chief for the IEEE Transactions on Communications. Prof. Zorzi has been responsible of a number of research projects sponsored by industry and government in the field of telecommunications, both in Italy and in the United States. His research interests include a broad range of topics in wireless networking and wireless communications.

Nicola Bui received the laurea (BS) degree in information engineering in 2003 and the Masters degree in telecommunication engineering in 2005, both from the University of Ferrara. He has been a research fellow with Consorzio Ferrara Ricerche (FERRARA), Ferrara, Italy, and with the Department of Information Engineering (DEI), University of Padova for four years. During this period he has been involved in three European funded projects: Ambient Networks, on heterogeneous networks, e-SENSE and SENSEI, on wireless sensor networks. He is also the general manager of Patavina Technologies, a spin-off of the University of Padova, operating in the ICT field. His main research interests are focused on the design, simulation, and experimentation of protocols and applications for wireless sensor networks and embedded systems.

MEDIApro, Barcelona, Spain

MEDIAPRODUCCION, S.L. (MEDIAPRO), www.mediapro.es, is a Spanish business group in the communication industry that includes all the technical and creative personnel necessary to set up and broadcast any type of audiovisual creation. MEDIAPRO has a presence in the audiovisual contents production sector; in sports (MEDIAPRO is the TV rights owner of most Spanish football teams, Formula1 and the Basketball Euro league) and also manages cinema rights, consultancy services related to television and sports; creation, design and production of themed channels, different formats and genres for television; cinema production and interactive content; as well as in post-production services.

Technical engineering in the broadcast field, broadcast and marketing and business plan services, communication and advertisement commercialization are other activities developed by the group. Through its own subsidiaries, participating companies and partnerships with outstanding companies in their markets (like France Telecom, Carlton Communications, Portugal Telecom Mutimedia, Grupo Planeta, Grupo De Agostini, Sports Five and El Deseo), MEDIAPRO has become one of the main groups in the audiovisual market. With a worldwide workforce of more than 3000 people the group reached a turnover of over 1000 millions Euros.

MEDIAPRO is the leading provider of post-production services in Spain, through its presence in the two most outstanding markets, Madrid and Barcelona, and keeps a preferential position in South Europe. Highly-qualified professionals equipped with the most advanced technology, provide multimedia solutions for advertising, cinema, television, themed channels, concerts and interactive experiences to a worldwide client base.

Additionally, MEDIAPRO is currently exploring IPTV and network distribution solutions that will allow the online access to its rich media contents to a worldwide audience using the latest technology advances. MEDIAPRO Research is coordinating and leading a consortium of 12 companies and 19 research groups for the project i3media (www.i3media.org) partially funded by the Spanish government and it is a prominent member of the EU funded projects 2020 3D Media (FP7 IP) and Apidis (FP7 STREP). MEDIAPRO is also leading FINE project

(FP7 STREP). The participation of MEDIAPRO in DiaMus will concern to several areas. We will be in charge of the business plan and dissemination activities.

Joan Bennassar is MEDIAPRO's Research Director and Associate Professor at Pompeu Fabra University. He is Electrical Engineer by UPC (Barcelona). He worked at BMCI (Barcelona Media Centre d'Innovació) as Innovation Director, Partner at Netjuice Consulting, General Manager at NetProfit and Director of Internet & Electronic Business at EDS, where previously was Senior Consultant, being responsible of the technological design of the Results Management System of Barcelona '92 Olympic Games. He has participated in several competitive European projects such us IP-Racine, IP-Salero, ICING, IP-2020 3D Media and Apidis. Currently is coordinating the Spanish CENIT project i3media.

Sergi Sagas is MEDIAPRO's Director of Research. After receiving a BSc in Computer Science, he moved to Los Angeles where he graduated in Film and TV production at UCLA. In 1994 he started working at the Walt Disney Company as a Technical Director at the Feature Animation division, after 8 years of working at Disney he was hired at Sony Pictures Imageworks as a Lead Technical Director where he worked on both R&D and production projects. The work he and his team did for some of theses projects has gained international recognition and was credited with several prestigious awards including 2 Oscars and a Technical Achievement awards from the Academy of Motion Pictures Arts and Sciences.

Gustavo González is a Research Scientist and a PhD candidate in Artificial Intelligence. He obtained his Computer Science Engineering degree and his M.Sc. in Telecommunications in 1999 and 2001 respectively. In 2003, he obtained his M.Sc. on Information Technology. Currently he is working in MEDIAPRO Research in Barcelona, Spain. His work is focused on Data Mining and Machine Learning techniques to build Smart User Models through multidimensional data for personalized services in Ambient Intelligence scenarios. He was working in 2006 as Guest Researcher in the Fraunhofer Institute for Applied Information Technology (FhG-FIT) (Germany) in the wearIT@work project: "Empowering the Mobile Worker by Wearable Computing". His current research interests include user modeling, personalization of services in ambient intelligence, recommender systems and multi-agent and autonomic systems. Mr. González is an IEEE Member since 2004 and Programme Committee Member of a number of International Research Conferences and Scientific Journals: MobileHCI2009, RecSys2009/2010 (ACM Conference on Recommender Systems 2009), UMAP2009 (International Conference on User Modeling, Adaptation and Personalization. Industry Track), EuroITV2008/2009 (European Interactive TV Conference), ICEIS2006/2007/2008/2009 (International Conference on Enterprise Information Systems).

Jordi Ramón graduated in Telecommunication Engineering by UPC (Barcelona) in 2004. In 2005, he obtained an MBA in directive skills by UAB (Barcelona). From 2004 to 2005 he worked in Vodafone Spain, at Quality and Revenue assurance Department. He specialized in Analysis and report on Quality of Service (QoS) in 2G and 3G networks, focused on customers as well as analysis and benchmarking on QoS in main Spanish cities and roads. He also worked in Al-pi Telecommunications as a network engineer in the Network control center. Currently he is working in MEDIAPRO Research in Barcelona as a Project Manager. Last years he has been managing i3Media Project (CENIT Spanish project). He is also

responsible of a work package in an FP7 project (2020 3DMedia) focused in Exploitation and business plans within 3D Digital Cinema, since 2008. Mr. Ramón is currently involved in a negotiation with EC regarding a new FP7 project whose coordinator is MEDIAPRO.

Institute of Orthopedic Surgery and Traumatology, Belgrade, Serbia

The Institute of Orthopedic Surgery and Traumatology is the oldest and most relevant institution in the country in terms of orthopedic disorders and bone and joint traumatology. It is an integral part of Clinical Centre of Serbia, the biggest health institution in Serbia. From the very beginning, it has been educational and scientific institution of Medical School, University of Belgrade. There are more than 50 medical doctors who work in 12 different departments, including microsurgery, reconstructive hand surgery, orthopedic trauma, hip surgery, aloarthoplasty, and scientific research. More than 3000 surgical procedures are performed at the Institute annually. The Institute of Orthopedic Surgery and Traumatology has been involved in many a number of national and international projects in medical and bioresearch fields and have gained significant experience. The comprehensive project list is available upon request.

Prof. Dr Marko Bumbasirevic is the Director of the Institute of Orthopedic Surgery and Traumatology, Professor of Orthopedic Surgery and Traumatology and the Chair of the Surgery Department. He studied at Medical School, University of Belgrade and successfully completed the programmes of undergraduate and postgraduate studies, as well as residency studies. In order to perfect himself, he had post-residency training at Institute Francais de la Main (Paris, France) under the mentorship of Professor Alain Gilbert during 1989 and 1990. Prof. Bumbasirevic is the President of Serbian Orthopedic and Traumatology Association (SOTA), member of the Academy of Medical Sciences of Serbian Medical Association, and the President of its orthopedic section. He used to be the Chief Coordinator of Yugoslav Association of Orthopedic Surgery and Traumatology in 2004, member of the national Committee of SICOT, member of ICS, IMS, WSRM, ASRM and ASPN, Honorary member of Society for Plastic and Reconstructive Surgery of Serbia and Montenegro and Macedonian Orthopedic and Traumatology Association. He was awarded French Government Scholarship for post-residency training, research grant Ministry of Science and Technology, Republic of Serbia, research grant Experimental and clinical study of reconstruction of injured extremities. He is also member of Editorial Boards Current Orthopedics, Romanian Journal of Reconstructive Microsurgery. He has been involved in a number of national and international bioresearch, orthopedic and traumatology projects.

Prof. Dr Vladimir Bumbasirevic is Dean of Medical School, University of Belgrade, Professor at the Department of Histology and Embryology, the member of University of Belgrade Council, the President of Programme Council of postgraduate studies in molecular medicine. He studied at Medical School, University of Belgrade and successfully completed the programmes of undergraduate and postgraduate studies. His most important research field has been histology and cell biology, as well as molecular mechanisms in apoptosis. He has been Principal Investigator on large number of national and international projects. Some of

the most significant ones are supported by the Ministry of Science and Technological Development of Serbia, the Ministry of Science and Environment, Serbian Academy of Science and Arts. He has also been involved as Chief Coordinator on several projects on education reform. He has been the member of Serbian Academy of Science and Arts since 2000, member of Medical Science Academy of Serbian Medical Association, member of European Microscopy Society, Microscopy Society of Serbia, Serbian Anatomical Society, Neuroscience Society of Serbia. He was honored with the prestigious award for medicine of City of Belgrade in 2005. He has also received university awards three times, as well as the award of Medical School.

Dr Darko Milovanovic graduated from Medical School, University of Belgrade in May 2004. He had additional trainings in bioresearch in the USA. He is currently employed at the Institute of Orthopedic Surgery and Traumatology and involved in three bioresearch projects.

Dr Slavisa Zagorac graduated from Medical School, University of Belgrade in March 2002. He spent a year at Medical School, University of Ulm, Germany. He is currently employed at the Institute of Orthopedic Surgery and Traumatology and involved in two bioresearch projects.

The whole team of Prof. Dr. Bumbasirevic consists of ten medical doctors, who could potentially be involved in the project.

University of Primorska, Koper, Slovenia

The University of Primorska (KOPUNI) was established in the year 2003 and is the third national university. The mission of UP is to generate and transmit new knowledge, disseminating it through technological innovation, and yielding training results in a wider Central European area and to lead to the formation of a creative expert and thinker as a result of educational processes based on research, innovations and practical training. Today

UP had 9 members – 5 faculties: Faculty of Humanities Koper, Faculty of Management Koper, Faculty for Mathematics, Natural Sciences and Information Technologies Koper, Faculty of Education Koper, Faculty of Tourism studies Portorož; one university college: College of Health Care Izola, two research institutions:

Science and Research Centre Koper, Primorska Institute of Natural Sciences and Technology Koper and Students' Residence. UP is co-founder of the University incubator of Primorska and The University carrier centre.

The research activity of UP is conducted at its facultie and especially at the two research institutes (UP ZRS and UP PINT). In the past 5 years within the university 50 international and more than 100 national research projects were successfully concluded. The research activity at UP is increasing every year, which is seen in the number of projects as well as in the increasing value in FTE point, which reached 66,42 in the year 2008. The basic research activity is conducted within 13 Research Programmes at 4 university members (UP FM, UP PEF, UP ZRS, UP PINT) in collaboration with other institutes or faculties.

.

Science and Research Centre of Koper

UP ZRS represents the key structure of the science and research activities of the University of Primorska and aims to become and internationally recognized science and research institution of reference in its science and research fields.

This activity is carried out within several projects of cooperation both with national and international academic and science and research environment in interaction with economic sector and the wider society. UP ZRS operates on a distinctive interdisciplinary basis (combining humanistic and social studies and natural sciences) and lays particular emphasis on the research of topics related to the Mediterranean, the Upper Adriatic area, central European and Slovenian area. The research activities of the centre are also focused on the human interaction with the environment, the influence of specific environments on the human organism and the application of research results in the professional international public. The presented research orientation of the UP ZRS also follows the aim to preserve the natural environment, biotic diversity, improvement of the quality of health and life and opposes to the negative reaction of the human organism to the modern/contemporary lifestyle.

With the exposed activities UP ZRS enriches the academic and social sphere at the local, Mediterranean and wider (domestic and foreign) level. The UP ZRS also assures the quality in on its fields of action and an also verified top-level science excellence. Within the CE the following institutes will be included:

Institute for Kinesiology Research enters CoE as a research partner in the field of kinesiology, physiology, nutrition and psychology. Research potential is evident in research excellence, international collaboration and importance. We have carried out four big international industrial projects. Furthermore, we are actively involved in leading of three international research groups (International Kinesiometrics Forum, Muscle Atrophy Research Group, Space for Health). At the same time we are very proud on the Laboratory for pathophysiology of human movement. Laboratory is equipped with state of the art diagnostic and measurement equipment. On the basis of our references we have just acquired a new program group Kinesiology for quality of life and also another basic research project. In very short period of time from our establishment (5 years) we are one of the best kinesiology research institutions.

Prof. Dr. Rado Pišot is full professor and his research fields are : kinesiology (biomechanical, medical and didactic aspect), motor development and the structure of motor space as part of the integral development of children, neurophysiologic basis of movement regulation (motor control), motor behavior and motor learning, the impact of motor/sporting activity on health and lifestyle. Rado Pišot was born on September 9, 1962, in Koper, Slovenia . After completing the Koper Grammar School, he graduated from the Faculty of Sport of the University of Ljubljana . He continued his studies at the Ljubljana Faculty of Sport and at the Faculty of Kinesiology of the University of Zagreb, and in 1994 took his master's degree. In 1997, he was awarded a PhD in kinesiology for his doctoral thesis titled The Model of the Motor Space of Six-and-a-Half-Year-Old Children Before and After Partialization of Morphological Characteristics.

His research findings have been published in various internationally acclaimed journals. He is the author and co-author of several scientific monographs, reference books and handbooks, as well as professional and scientific articles; he has edited several collections of papers and is a member of the editorial boards of Studia Sportiva (published by the Masaryk University, Brno) and Health Care (published by the Slovene National Institute for Health Protection). His works have been cited by Slovene and foreign scientists. He has also written numerous reviews of papers published in prominent foreign journals. He has worked on several international projects: Tempus, Comenius 1, Comenius 2, Intensive Program 1, Health Enhancing Physical Activity, Bed Rest Valdoltra 2006 and 2007 – The Influence of Simulated Weightlessness on the Human Organism, WADA 2007-2008. He has presented his research findings at Slovene and foreign universities and has been a guest lecturer at many foreign institutions.

He is the founding father of Ikarus – Institute for Kinesiology Research, an institute operating within the Science and Research Centre of the University of Primorska and the Valdoltra Orthopedic Hospital that developed from the second kinesiology research group in Slovenia. He is the head of and a researcher in several research projects: target research project (hereinafter TRP) Health Enhancing Motor/Sporting Activity, TRP Sport as an Element of Tourism Development: the Importance of Sport in Tourism - Products, Marketing and Strategy, TRP Competitiveness of the Slovene Sporting Market, TRP Preparation of Criteria for Selection and Retention of Slovene Soldiers in the Army (conducted in co-operation with the Slovene Ministry of Defense), TRP Combatant's Equipment (conducted in co-operation with the Slovene Ministry of Defense), TRP Influence of Various Behavioral Styles on Children; applied research project (hereinafter ARP) Function of Biomechanical Properties of Skeletal Muscles in a Child's Motor Development, ARP Monitoring Biomechanical Properties of Skeletal Muscles During Childhood and Adolescence and ARP Altitude Acclimatization.

He initiated and, together with his colleague Prof Igor Mekjavič from the Jožef Stefan Institute, organized and coordinated research in simulated weightlessness and its influence of the human organism. The research developed in a research programme Bedrest Valdoltra 2006, 2007 conducted in co-operation with several distinguished foreign researchers and institutions

As a full professor of motor activity and theory of sport with didactics, he lectures at the Faculty of Education of the University of Primorska, as well as at the Faculty of Education and Faculty of Sport of the University of Ljubljana and at the Faculty of Kinesiology of the University of Zagreb (postgraduate level). He has initiated and chaired four international symposiums titled Child in Movement. Together with the Jožef Stefan Institute and the Woolongong University from Australia, he organized the International Conference on Environmental Ergonomics (Piran 2007).

He was a member of the founding group of the University of Primorska (UP) and the first Dean of its Faculty of Education. He is the Head of the Institute for Kinesiology Research and a member of the UP Senate. With his rich expertise, he is a member of various professional bodies, be it Slovene or international: Expert Council for Sports of the Republic of Slovenia, Council for Health Enhancing Physical Activity operating within the Slovene Ministry of Health, CINDI, European College of Sport Science, Slovenian University Sport Association (Vice Chairman). He has been awarded the UP ZRS Herald of Science and the UP Golden Award for his work achievements. In December 2007, the UP Senate appointed him Vice-Rector for Science.

Gregor Cankar is assistant. His research field is kinesiology (biomechanical, medical and didactic aspect). Gregor Cankar was born on 25.1.1975 in Celje Slovenia. After secondary chemistry school finished Faculty of Sport at University of Ljubljana. Now he is attending postgraduate study programme at the Faculty of Sport. He co-published a scientific article, several chapters in scientific monograph. In 2008 he began to work in a Institute for Kinesiology research at University of Primorska as a young researcher.

Matej Plevnik is young researcher. His research field is kinesiology (biomechanical, medical and didactic aspect). Matej Plevnik was born on 21.7.1981 in Ljubljana Slovenia. After gymnasium he finished Faculty of Sport at University of Ljubljana. Now he is attending postgraduate study programme at the Faculty of Sport. He is co-author of a professional book – Swimming for dystrophic patients. In 2009 he began to work in an Institute for Kinesiology research at University of Primorska as a young researcher.

Barcelona Supercomputing Centre, Barcelona, Spain

Early in 2004 the Ministry of Education and Science (Spanish Government), Generalitat de Catalunya (local Catalan Government) and Technical University of Catalonia (UPC) took the initiative of creating a National Supercomputing Center in Barcelona. BSC-CNS (Barcelona Supercomputing Center – Centro Nacional de Supercomputación) is the National Supercomputing Facility in Spain and was officially constituted in April 2005. BSC-CNS manages **MareNostrum**, one of the most powerful supercomputers in Europe, located at the Torre Girona chapel. The mission of BSC-CNS is to investigate, develop and manage information technology in order to facilitate scientific progress. With this aim, special dedication has been taken to areas such as Computational Sciences, Life Sciences and Earth Sciences. All these activities are complementary to each other and very tightly related. In this way, a multidisciplinary loop is set up: our exposure to industrial and non-computer science academic practices improves our understanding of the needs and helps us focusing our basic research towards improving those practices. The result is very positive both for our research work as well as for improving the way we service our society.

Mario Nemirovsky is Network Processors Group Manager at the Department of Computer Sciences – Network Processors, at Barcelona Supercomputing Centre.

Faculty of Electrical Engineering, University of Ljubljana, Slovenia

This faculty was founded in 1950, 31 years after the University of Ljubljana was established. Today, it is one of the largest faculties in the university with long tradition in research and education. UL-FE is the leading national institution offering undergraduate, postgraduate and professional education, and carrying out research in the fields of automatics, electronics, telecommunication and power engineering. Currently we employ 290 personnel and 2177

students are fully registered. Research at the UL-FE is carried out in all major fields (electrical energy, electric machines and power electronics, electronics, microelectronics and biomedicine, measuring systems automation and cybernetics, robotics and telecommunications) by 239 registered researchers working in 47 laboratories.

The Laboratory of Communication Devices (LKN) lead by Prof. Dr. Saso Tomazic, has for the last decade been engaged mainly in research of digital communication systems. The LKN lab research activities in this broad area include: communication protocols and software development, modelling and simulation of communication networks, spread spectrum coding , secure communications and distributed database archiving systems.

Currently the main research program are optimization methods and algorithms in communications.LKN lab research activities also include adaptive digital signal processing in communications, acoustic signal processing and spatial sound processing. The other field of interest is the study of multilingual machine translation methods based on the formal computer language e-speranto. All members of the laboratory are also involved in the organization of the VITEL symposiums and workshops and VIPSI conferences in Bled.

Dr. Anton Umek has work experience as senior lecturer in courses like: Telecommunication networks, Adaptive signal processing, Secure communications, Elements of communication systems, Digital signal processing, Telecommunication Basics, Digital Communications, Telecommunication Circuits.

Dr. Jaka Sodnik as a member of the Laboratory for Communication Devices is an active researcher in the fields of computer networks, mobile networks of 2G and 3G and acoustics. Lately his research is focused on the generation of spatial sound with the use of Head Related Transfer Functions and its application in human computer interaction. The main goal of this research is the creation of an acoustic image of space as a navigation tool for blind people. His resent publications describe the studies of spatial sound perception and human abilities of localization of virtual sound sources. As a visiting researcher at the HIT Lab New Zealand, Jaka Sodnik was involved in several research projects in the field of augmented reality.

Dr. Jaka Sodnik selected publications are:

Sodnik Jaka, Dicke Christina, Tomažič Sašo, Billinghurst Mark. A user study of auditory versus visual interfaces for use while driving. Int. j. human-comput. stud., May 2008, vol. 66, no. 5, pp. 318-332.

Sodnik Jaka, Sušnik Rudolf, Štular Mitja, Tomažič Sašo. Spatial sound resolution of an interpolated HRIR library, Applied Acoustics, 2005, vol. 66, no. 11, pp. 1219-1234.

Sodnik Jaka, Sušnik Rudolf, Tomažič Sašo. Principal components of non-individualized head related transfer functions significant for azimuth perception. Acta acustica united with acustica, 2006, vol. 92, no. 1, pp. 312-319.

Sušnik Rudolf, Sodnik Jaka, Tomažič Sašo. An elevation coding method for auditory displays. Applied Acoustics, 2007, in press.

Sodnik Jaka, Štular Mitja, Milutinović Veljko, Tomažič Sašo. Mobile communications : 4G. V: FURHT, Borivoje (ur.). Encyclopedia of wireless and mobile communications. Boca Raton; New York: Taylor & Francis Group: Auerbach Publications, cop. 2008, vol. 2, pp. 634-642, ilustr.

Dr. Dragan Savic area of research are Simulation data exchange in Telecommunications, research project COST 285 - Modelling and Simulation Tools for Research in Emerging Multi-service Telecommunications, journal paper: CostGlue: Simulation Data Exchange in Telecommunications, 2004 – 2007. Also, he is active in research in Communication Networks, work funded by the Ministry of Higher Education, Science and Technology of the Republic of Slovenia (program P2-0246), paper: Transport Protocol Dependent Communications in Different Packet Switch Architectures.

Laboratory of Micro sensor structures and electronics - LMSE offers complete R&D services in the field of silicon semiconductor devices, (smart) sensors, actuators, MEMS and involved electronics, from theoretical analysis to development of test structures and devices, their characterization and optimization. LMSE products include silicon based photo sensors, pressure sensors, temperature sensors, radiation sensors, 3D MEMS structures, micro reactors, micro fluidic structures, etc. In LMSE also cooperation with students and young researchers in mentioned research activities is strongly supported.

Dr. Slavko Amon received his B.S. degree in physics from Faculty of Natural Sciences and Technology, University of Ljubljana, Slovenia in 1970, M.Sc. and Ph.D. in electrical engineering, in 1976 and 1981 respectively, both from Faculty of Electrical Engineering, University of Ljubljana, Slovenia. In 1970, he joined the Laboratory of microelectronics at Faculty of Electrical Engineering, University of Ljubljana, Slovenia, where he worked as a research engineer in the field of planar silicon technology and devices. In addition, from 1973 to 1982 he was engaged at Faculty of Electrical Engineering, University of Ljubljana, Slovenia as Assistant. In 1982 he was appointed Assistant Professor, in 1987 Associate Professor, and in 1992 Full Professor, giving courses in fundamentals of semiconductor devices, electron components, sensors and actuators. In 1998, he established a laboratory, now called Laboratory of Micro sensor Structures and Electronics. In 1978, he was on a six-month research visit at the Laboratoire de Microelectronique, UCL, Louvain-La-Neuve, Belgium as “Chercheur libre”, working on new MOS technologies. During the academic years 1992-1993 and 1994-1995, he was Visiting Professor at Trento University, Italy, teaching and doing research in the modeling of semiconductor devices.

Work in Professional Institutions in Slovenia and abroad:

- Head of Laboratory of Micro sensor Structures and Electronics
- Head of Laboratory of Electron Devices
- Head of Laboratory of Nonlinear Devices
- Head of Laboratory for Optoelectronics
- Head of project group for research of monocrystal semiconductor structures
- President of Commission for Human Resources FER

- Secretary of Society of University Professors, University of Ljubljana
- Secretary of Association of University Professors Societies of Slovenia
- President of Commission for rewards and acknowledgments, Society of University Professors UL
- President of Editorial Board of intl. journal Informacije MIDEM
- Vice-president of International Society MIDEM
- President of Program Committee of International Conference MIEL-SD'91
- President of Program Committee of International Conference MIEL-SD'96
- Editor of MIEL-SD'91 Proceedings
- Editor of MIEL-SD'96 Proceedings
- Member of International Program Committee, 41 st. Annual Conference KoREMA '96
- Co-President of Program Committee of International Conference MIDEM '96
- President of Program Committee of International Conference MIDEM '99
- Member of International Program Committee, MIPRO, in period 2001-2006
- Head of European Project MINOS-EURONET for Slovenia, 6 FP: Micro-Nanosystem European Network, Specific Support Action, Contract No. 015704)
- Coordinator of European Project Socrates Minerva, Grant Agreement No. 116947-CP-1-2004-SI-MINERVA-M
- reviewer of research projects at Ministry of science, higher education and sport of R Croatia, since 2006
- reviewer of international conference EUROCON 2005
- reviewer for international journals (J.Micromech.Microeng., Sensors and Actuators, IEEE Electron Device Letters, IEEE Transactions on Electron Devices)
- Head of European Project MINAEAST-NET for Slovenia, 6 FP, Contract No. 510470
- Slovenian representative in the Scientific Community Council of European Technology Platform for Nanoelectronics ENIAC
- President of International Society for Microelectronics, Electronic Components and Materials - MIDEM, since 2005
- Member of International Advisory Board of CIMTEC - International Conference on Smart Materials, Structures and Systems, since 2007

Dr. Drago Resnik received the B.Sc., M.Sc. and Ph.D. degree from the University of Ljubljana, Slovenia in 1984, 1993 and 2000, respectively. In 1984 became employee of Iskra – semiconductor manufacturer in Trbovlje as research engineer on field of bipolar technology process and new devices. Since 1991, he is doing research in the Laboratory of Microsensor Structures, Faculty of Electrical Engineering, University of Ljubljana, on design, processing and characterization of semiconductor devices. From 2003, he is engaged as an Assistant Professor at the University of Ljubljana, Faculty of Electrical Engineering, Slovenia. His

current research interest includes development of silicon micromachining and MEMS technology related to modern sensors and actuators structures. Dr. Resnik was a leader of R&D project "Technology of Silicon Pressure Sensor". Currently, he is a leader of R&D project "Implementation of new micromachining technology and smart electronics in pressure and opto sensors".

Dr. Danilo Vrtačnik received the B.Sc., M.Sc. and Ph.D. degree from the University of Ljubljana, Slovenia in 1981, 1994 and 2000, respectively. Since 1991, he is doing research in the Laboratory of Microsensor Structures, Faculty of Electrical Engineering, University of Ljubljana, on design, processing and characterization of semiconductor devices. In 1995, he was a Visiting Researcher at the Instituto per la Ricerca Scientifica e Technologica (IRST), Trento, Italy. From 2003, he is engaged as an Assistant Professor at the University of Ljubljana, Faculty of Electrical Engineering, Slovenia. His current research interest includes development of silicon radiation detectors and related photo devices as well as modern sensors and actuators structures fabricated by MEMS technology and coordination of R&D project Microstructures and Microsystems which is a part of Center of Excellence: Materials for Electronics of next generation and other emerging technologies (RRI CO-ME). Recently, he is included in numerous international and domestic projects and networks in the field of research and development. He acts as organizer and chairperson of International conference MIDEM and as Reviewer in scientific Journals and for Institutions.

Dr. Matej Možek, working experience encompasses: Jozef Stefan Institute, Dept. of Professional Electronics. Assistant. (1990), Institute of Welding Ljubljana. Computer programmer (1993), Metronik d.o.o. Project of a temperature sensor PT1000 driver (1996), Jozef Stefan Institute, Dept. of Biocybernetics. Computer programmer (1997 - 1998), Elsis d.o.o., design of AC power lamp regulation with microcontroller controlled Insulated Gate Bipolar Transistor. Application engineer (1998 - 1999), LMSE, Faculty of Electrical Engineering University of Ljubljana, Tržaška 25. Research assistant / postgraduate student (1999), HIPOT-HYB d.o.o. MAP (Manifold absolute pressure sensor). Computer programmer (2003), HYB d.o.o. Smart calibration systems for pressure sensors. Computer programmer (2003), LMSE - FE Faculty of Electrical Engineering University of Ljubljana, Tržaška 25.31.12.2008. Researcher, assistant prof. (2004).

Faculty of Computer and Information Science, University of Ljubljana, Slovenia

The Faculty of Computer and Information Science, University of Ljubljana, is the leading teaching and research institution in the field of Computer Science in Slovenia, and in spite of its comparatively short history it has a number of active research groups, as well as a lengthy roster of alumni, some of whom have achieved distinction in various fields of computer science in Slovenia and abroad. The faculty consists of six groups, including Software, Computer Logic, Systems and Networks, Informatics, Theoretical Computer Science, Artificial Intelligence and Mathematics and Physics, which comprise seventeen research laboratories with more than 150 employees. The variety of research groups enables the comprehensive coverage of computer science and IT fields. In accordance with the research variety is also research equipment. From the organizational point of view the faculty has all the means necessary to manage economic, national and international projects. The research

activities are financed mostly through projects from Republic of Slovenia and European Union. The research budget in year 2008 was more than 1.130.000 Euros.

Professor Nikolaj Zimic has received his BSc degree in 1984, MSc degree in 1990 and PhD in 1994, all in Computer Science from the Faculty of Computer and Information Science, University of Ljubljana. He is currently employed as a Professor at the Faculty of Computer and Information Science, University of Ljubljana, where he holds the position of head of the Computer Structures and Systems Laboratory.
His pedagogical activities comprise lectures of Computer Systems Performance and Evaluation, Switching Structures and Systems, Logic Design of Computers and Computer Modelling and Simulation and mentorship at one PhD thesis, one Prešeren prize thesis, 3 master theses and 52 bachelor theses.
Professor Zimic holds the position of Vice Dean for Development and is a member of the faculty administrative board and the committee of staff matters. He is the chair of the Board of Information System Development at the University of Ljubljana.
He and his laboratory currently cooperate with the following institutions Università degli Studi di Padova (Italy), Kharkiv Polytechnical Institute (Ukraine), Technical University of Varna (Bulgaria), Joanum Institute Graz, Kapfemberg Department (Austria) and University of Rhode Island (USA). He has authored/coauthored 185 scientific contributions. He reviewed several conference and journal contributions, among others: Fuzzy sets, Mathematical and Computer Modelling of Dynamical Systems and Electrotechnical Review.
He is involved in several research projects for the Slovene industry (Iskratel Kranj d.o.o., Elektronček d.d., Ourspace d.o.o., etc). He supervised (including directing the analysis and start up) the renovation of the Slovenian Parliamentary voting system that successfully operates for several years.

Associate professor Miha Mraz has received his BSc degree in 1992, MSc degree in 1995 and PhD in 2000, all in Computer Science from the Faculty of Computer and Information Science, University of Ljubljana. In year 2001 he was elected in to position of Assistant Professor and in 2006 in to position of Associate professor, both at the Faculty of Computer and Information Science, University of Ljubljana. Currently he holds lectures of Introduction to Modelling and Simulation, Computer Reliability and Diagnostics, Evaluation of Computer Hardware and Optical and Nanotechnologies. He has authored/coauthored more than 100 scientific contributions and was a mentor at 4 master theses and 32 bachelor theses. As a member of the Computer Structures and Systems Laboratory he cooperates with the following institutions Università degli Studi di Padova (Italy), Kharkiv Polytechnical Institute (Ukraine), Technical University of Varna (Bulgaria) and Institute for broadband communications, Technical University of Graz (Austria). He is active reviewer of journal and annual conference Microelectronics and Microengineering. He is also actively involved in several research projects for the Slovene industry (Iskratel Kranj d.o.o., Elektronček d.d., Ourspace d.o.o., etc).

Iztok Lebar Bajec has received his BSc degree in 2000, MSc degree in 2002 and PhD in 2005, all in Computer Science from the Faculty of Computer and Information Science, University of Ljubljana. He is currently employed as an Assistant Professor at the Faculty of Computer and Information Science, University of Ljubljana. His pedagogical activities comprise lectures for Skills in Scientific Work I at the postgraduate level and tutorials for

Computer Systems, and Switching Structures and Systems at the undergraduate level. He acted as advisor for one BSc thesis and co-advisor for one MSc thesis, five BSc theses and one Prešeren thesis. He has co-authored more than 60 scientific publications and published fifteen original scientific articles, some in leading international journals like Nanotechnology, Animal Behaviour, and Journal of Theoretical Biology. He acts as an occasional reviewer for Physical Review E, Ecological Modelling, SIGGRAPH's Sandbox, and Information Sciences. His research interests include multi-valued logic, fuzzy logic, ternary quantum-dot cellular automata, graphics design and visualization, computer graphics, as well as modelling and simulation of complex systems like organized flight in birds. As a member of the Computer Structures and Systems Laboratory he is also collaborating at several research and development projects in the fields of telecommunications, medicine, embedded systems and defence.

Primož Pečar has received his BSc degree in 2004 and MSc degree in 2007, both in Computer Science from the Faculty of Computer and Information Science, University of Ljubljana. He is currently employed as a Teaching Assistant at the Faculty of Computer and Information Science, University of Ljubljana and is in charge of tutorials for several courses, including Computer Systems Performance and Evaluation, Evaluation of Computer Hardware, Computer Reliability and Diagnostics, Optical and Nanotechnologies. His research activities include alternative processing platforms, with current focus on quantum-dot cellular automata, nanotechnology, embedded systems, fuzzy logic, programmable hardware and evolware. He is currently pursuing his PhD in ternary quantum-dot cellular automata. As a member of Computer Structures and Systems Laboratory he is also collaborating at several research and development projects in the fields of telecommunications, medicine, embedded systems and defense.

Miha Moškon has received his BSc degree in 2007 in computer science from the University of Ljubljana and is currently pursuing his PhD at the same university. He is employed as a Teaching Assistant at the Faculty of Computer and Information Science, University of Ljubljana and is in charge of Logic design and computers, Introduction to modelling and simulation and Distributed Systems practical courses. His research activities are directed towards fuzzy logic, artificial life and alternative processing platforms, with current focus on synthetic biology and computing with proteins. As a member of Computer Structures and Systems Laboratory he is also collaborating at several research and applicative projects in the fields of telecommunications, medicine, embedded systems and defense.

Patrcio Bulić has received his BSc degree in 1998 in Electrical Engineering, and MSc degree in 2001 and PhD degree in 2004 in Computer Science from the Faculty of Computer and Information Science, University of Ljubljana. He is currently employed as an Assistant Professor at the Faculty of Computer and Information Science, University of Ljubljana and a visiting professor at Faculty of Electrical Engineering, University of Banja Luka. His pedagogical activities comprise lectures for Review topics in Computer Science at the postgraduate level, Computer Graphics at undergraduate level and tutorials for Computer Architecture, Computer Graphics, Introduction to computer Systems, Computer Organization,

Parallel Architectures at the undergraduate level. He acted as an advisor for 12 BSc theses. He has co-authored more than 30 scientific publications and published eight original scientific articles, some in leading international journals. He acts as an occasional reviewer for the Journal of Supercomputing and Electro technical Review. His research interests include computer architecture, parallel processing, digital design and embedded systems. As a member of the Laboratory for Computer Architecture he has also collaborated at several research and development projects in the fields of telecommunications, medicine and embedded systems.

Assistant Professor Mira Trebar has received her BSc degree in 1981, MSc degree in 1992 in Electrical Engineering, University of Ljubljana and PhD in 1997 in Computer Science from the Faculty of Computer and Information Science, University of Ljubljana. She is currently employed at the Faculty of Computer and Information Science, University of Ljubljana where her main pedagogical responsibilities comprise of following lectures: Introduction to Computation, Programming, Digital Logic Design, Distributed Structures and mentoring students with their bachelor thesis. She is a member of a Laboratory for Computer Architecture and is involved in research activities of soft computing methods, computer systems and radiofrequency identification in a supply chain management with publications as an author/co-author including 35 scientific contributions. Lately, she is a frequent reviewer of journal contributions for Computer and Application in Engineering Education. Currently, the cooperation with the University of Wolverhampton (UK), an Austrian Company (RF-iT Graz), and one Slovenian Company (Select d.o.o.) takes place in her research and expertise work and she is in the negotiation process of an EU funding project for years 2010-2011.

OurSpace, Ljubljana, Slovenia

Jurij Božič is the CEO of OUR SPACE d.o.o. He has run and managed several high profile IT projects in companies as HELIOS d.d. (implementation of a new ERP), ELEKTRONABAVA d.o.o. (implementation of a new ERP, development of new IT products), BERNARDIN HOTELS (reorganization of the IS), ELES d.o.o. (business process management) etc. Currently he acts mostly as a senior consultant for the management boards in several companies such as HELIOS, ELEKTRONABVA etc.

Gaber Cerle has graduated in 2004 at GEA College of Entrepreneurship continuing his study at the Faculty of Criminal Justice entering the course of Information science and security specialization. He started working for OUR SPACE d.o.o. in 2007. His work consists of managing the work of consultants, project management in commercial and governmental financed projects, business consulting etc. As a project manager he has been involved in the implementation of a HRM information system based in MERKUR GROUP and in the implementation of the ERP in Geodetski zavod Slovenije d.d. He has also been involved in the project FLEXSCREEN for the Ministry of Defense and in business process management for ELES d.o.o. He is currently managing two large R&D projects one financed by the Ministry of Defense and the other financed by the Ministry of the Economy. He is also ITIL SLM and PRINCE2 certified.

Andrej Komatar has graduated in 2005 at Faculty of Computer Science, University of Ljubljana. After graduation started working in OUR SPACE d.o.o. on maintaining and implementing ERP systems (Scala, Oracle EBS). Later on he was programming web services, web parts and java script in Aris for ELES d.o.o. Recently he was developing software for Tensiomyography and is now working on implementing project management (Prince2 metodology) in Sharepoint and implementing Oracle EBS (programming OAF) on Nuclear Power plant Krško. He is PRINCE2 certified.

Mojca Miklavčič graduated in 2005 at Faculty of Economics, University of Ljubljana. She is currently working as computer programmer in Our Space d.o.o. On recent projects she programmed web parts for MS SharePoint for ELES d.o.o. Ljubljana and acts as a technical consultant for Oracle ERP implementation projects at Nuclear Power Plant Krško, Unior d.d. Zreče and IUV d.d. Vrhnika.

Tomaž Nartnik is an associate and employee of Our Space d.o.o. from January 1998. His tasks involve building web and desktop applications, administering different versions of Microsoft platforms (Windows Server, Windows 2000 / XP / Vista) and Servers (SQL, IIS, SharePoint, Exchange, ISA). He specializes in building web applications which extend functionalities of standard ERP systems to web platforms for known clients as well as building stand-alone web applications and presentations based on own Content Management System. He was involved in projects for Eles d.d, Paloma d.d., Holding Ljubljana d.o.o., Elektronabava d.o.o., Helios d.o.o, Atrij Stanovanjska zadruga z.o.o. and many other clients. His references include building web interfaces to ERP systems Scala and BAAN, as well as developing desktop applications for process automation in the area of data exchange on different payment methods in Slovenia. He also specializes in support, development and administration of Windows SharePoint Services and MS Office Share Point Portal Server.

Mateja Hafner is as a IT consultant. She has been involved in HRM implementation project for MERKUR GROUP. She has also been working as a consultant on development of flexible display equipped with communication interface called FLEXSCR financed by Ministry of Defense. She is also project manager in business project management (BPM) for company ELES d.o.o. As a project manager she uses PRINCE 2 and has knowledge in the field of Information System Architecture, security and revision. She is PRINCE2 certified.

Ursa Pleterski is a member of BPM project for company ELES d.o.o. She has also been working on development of flexible display equipped with communication interface called FLEXSCR financed by Ministry of Defense. She has knowledge of ARIS Architect / Toolset and is responsible for BPM activities in several projects.

Vera Petrlin has long term experience in managing finance and accounting departments in big international companies and was responsible for reporting under Slovenian Accounting standards and US GAAP as well. She was one of the key users and support inside company Goodyear Sava Tires during implementation of the new information system (SAP).

In January 2007 she joined OUR SPACE GROUP as a Consultant and Project Manager and she collaborated in development and introduction of E-Business Suite applications: General Ledger, Account Receivable, Account Payable, Cash Management, Fixed Assets, assistance in development and implementation of VAT Books, reports for Bank of Slovenia, Statistical reports and other special reports. Currently she is working in BMP projects in ELES d.o.o. - managing and measuring of effectiveness of business processes in ELES, where she uses ARIS toolset for modelling.

Srđan Crevar is a ERP consultant, developer and leads project support. He has been working on implementing and supporting ERP in companies like MDK d.d., ELECTROLUX, Syngenta AGRO d.o.o., KRAS d.d., HOLDING, MERCK, NOVAMARK. His expertise in project support and administration began with administration of the FLEXSCREEN project financed by the Ministry of Defense. He also manages the two R&D projects one financed by the Ministry of Defense and the other financed by the Ministry of the Economy.

2.3 Consortium as a whole

An excellent mix of competencies, research interests and approaches is present in the consortium. This versatility and mix of complementary skills combined with the mutual understanding gained in previous collaborations will be utilized to the greatest possible extent to cross fertilize the best practices and increase research potential of everyone involved. The resources needed for research support and management activities are integrated from a variety of academic organizations and a large multinational company.

Research focus and expertise covered by the involved organizations spans the complete problem area covered by this proposal. In addition to that, both academic and industry oriented views of the research problems and challenges and consequently approaches are present in the project which ensures a holistic view of the research domain and is an additional added value of the consortium.

Also, where and when necessary, sub-contracting and engagement of experts will be done. Budget for this comes from the S&T coordinator’s budget.

Sub-contracting: For the amount of money up to 4% of the value of the project, coordinator institution can sub-contract (from its share) external organization, for implementing any activity for which the whole consortium determines that is mission critical. All subcontracting activities must be approved by the project leader and the entire consortium.

ii) Expert-engagement: Three external experts from the US will be engaged in the project. These experts are experienced and well-known researchers. They will present the state-of-the-art research in the US, as well as future research directions and will significantly contribute to the overall project objectives.

2.4 Resources to be committed

Mobilization of resources

The resources needed for the project activities are integrated from a variety of academic organizations and one large industrial partner. The resources profile and the participating partners are complementary in many respects. The project targets both shorter term and longer term activities that will set the basis for sustainable collaboration between the partner organizations and takes great care of particular regional strategic needs. External experts that agreed to take active part in project activities will bring additional expertise into the project and will improve the impact of the project both in terms of the project and its partners' promotion as well as in more extensive people networking opportunities.

Acquisition of new resources

The resources needed for PoC implementation and testing in the widest sense are difficult to estimate precisely at this point, and the suggestion is that they be allocated on the level of E40K (and extra money returned, if not used).

Travel related resources

The resources needed for travel and communications in the widest sense are difficult to estimate precisely at this point, and the suggestion is that they be allocated on the level of E260K (and extra money returned, if not used).

Financial plan

The Consortium has pulled together total of 600 man months of which 7% is allocated to management and the remaining effort to specific support activities. The total estimated budget for the project is about 4.000.000,00 Euro.

3 Impact

3.1 Expected impacts listed in the work programme

The project will advance state-of-the-art of the existing micro system/sensor networks in terms of size-function integration, reliability, and in addition, there will be a direct positive impact on the health and economy of EU citizens. Aging is a problem of EU, which requires effective solutions related to wellness, rehabilitation, and sports (health range).

Estimates from EU Member States of the economic costs of all work related ill health range from 2.6 to 3.8% of Gross National Product and a high proportion, up to 40-50% of the costs will be for musculoskeletal disorders. This means a coast between 215 to 314 billion EUR in EU in year 2008. The main product of this project is expected to become a market highlight.

The work of this project has a perfect match with the requirements of the Objective for which it was targeted to. The main steps to achieve the goal are careful development of use cases, precise implementation of the support technology, testing of the entire system in versatile environments, and dissemination, both on the commercial and scientific domains. This effort is cross-cultural and requires international efforts. For the final success, a statistically large enough test pattern has to be generated.

This type of technology is of interest to the owners of the medical, rehabilitation, wellness, and sports business, to the customers in the same arena.

Due to the fact that concrete use cases will be fully elaborated, and due to the fact that only the feasible aspect of the underlying theory will be implemented, the reusability of this technology will be easy. This means that beneficiaries of this technology will be able quickly to develop their new businesses based on this technology.

Export is expected not only to the USA, but to fast growing economies, where high volumes require an adapted business model, different from the one to be used in the USA. This is especially likely due to the fact that the underlying business model is simple.

This project will also have a strong impact on each partner. This responsible for technology development will become even more advanced in their domains. This responsible for the development of use case scenario will be offering the developed use case scenario to other environments, too. The institutions that will serve as test beds will become more sophisticated in the technology domain.

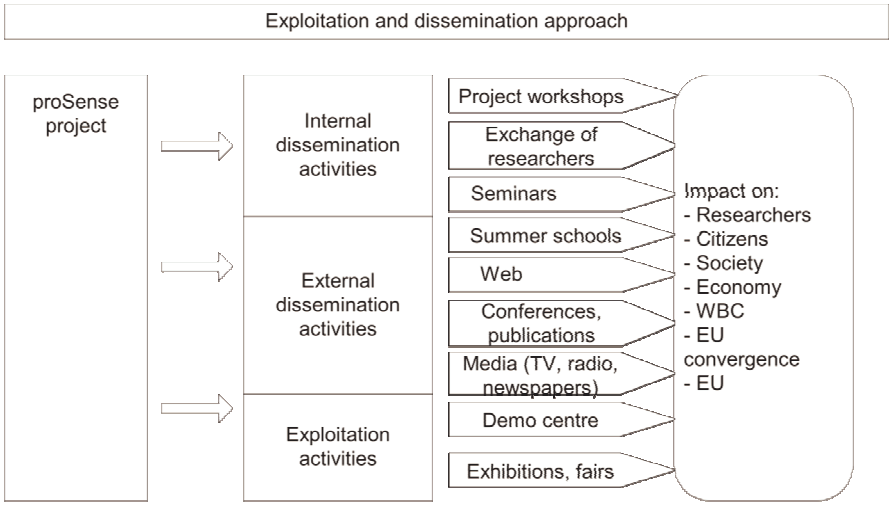
The work of this project has a perfect match with the requirements of the Objective for which it was targeted to. The main steps to achieve the goal are careful development of use cases, precise implementation of the support technology, testing of the entire system in versatile environments, and dissemination, both on the commercial and scientific domains. This effort is cross-cultural and requires international efforts. For the final success, a statistically large enough number of participants (for summer and winter schools) have to be gathered together.

3.2 Dissemination and/or exploitation of project results, and management of intellectual property

Dissemination is grouped into two major groups of activities: internal and external. The internal activities are targeting researchers from the organizations participating in the project, in particular those coming from the WBC and the EU's convergence region. A series of project workshops, lectures and exchanges of researchers are planned to address this need. The external activities are what is usually referred to when dissemination is discussed. These activities are targeting research community, general public and industry in order to promote results and achievements of the project. The following external dissemination channels and activities are planned:

- Web Site and Presentation
- Demonstration of new research infrastructure
- Summer schools, conferences and publications
- Exhibitions and Seminars
- Access through media (local TV and radio stations, newspapers).

Presentation of the wireless sensor networking technology and in particular of various applications based on this technology at industry oriented workshops and in the research premises equipped with the new research equipment will target the local SMEs to generate interest and highlight business potential. Additional track of the exploitation activities will be directed towards other research institutions in the WBC region to present achieved improvements in the research programs and educational curriculum in an effort to initiate similar changes throughout the WBC and create a wireless sensor networking cluster of excellence.



External dissemination and exploitation objectives

The project plans to set up a dedicated web site to make the project information available to a wide audience and to connect wireless sensor networking research community in the region. A public mailing list will be setup to disseminate the latest updates to interested users. A discussion board will be available for on-line discussions. The following information will be provided on the web site:

- Project objectives and achievements.
- Public deliverables in electronic forms.
- Key persons and contacts.
- Advertisement and announces of forthcoming public events organized by the project (summer schools, special sessions, seminars)
- Open opportunities for people travels
- Reports on events completed and project updates.
- Technical achievements and demo information/updates.
- Co-operation with similar projects/external bodies, and references to publications and other miscellaneous information.

The objective of the web site and presentation is to provide an entrance point for the community and make sure that the project is appropriately presented and represented and that:

- The project is widely known and information is easily accessible;
- The project objectives, aims and scientific approaches are well understood.

Two summer schools are planned by the project, one each year. Each summer school will have a different main theme. The objective of organizing summer schools with experienced researchers as lecturers is the following:

- To make body of advanced wireless sensor networking knowledge accessible to younger researcher in a relaxed environment;
- To provide networking opportunities to young researchers;
- To provide opportunities to young researchers to present their work to the peer researchers and get a valuable feedback.

The objective of the participation in conferences and the submission of publications is to ensure that:

- Network of competence for the project’s subject is building up and maintained;
- The scientific concepts and approaches are widely discussed and feed back solicited

- The understanding of the project's paradigm is penetrating academic and general community.

The objective of the participation in exhibitions is to ensure that:

- Particularly the industry and the ultimate end users are aware of available technology and its potential;
- The demonstrations with hands on experience provoke feed back to be able to improve the results.

Dissemination through standard media channels is a traditional way of promotion, which includes local newspapers and scientific or administrative publications, newsletters, television and radio at a local or a national level, brochures, CD-ROMs, etc. The objective of dissemination through media channels is as follows:

- To enlarge awareness of the technology and applications in the local community;
- To promote researchers in the local community.

This is a continuous action preferably through channels that the project partners already use, or have easy access to.

Dissemination through events

The project will organize and participate at a number of events: workshops, conferences, seminars, summer schools, public lectures, etc. Some of the events organized by the project will be for the project participants and selected audience only. The project will also organize a number of events, presentations and lectures targeting audience outside of the project itself independently or in conjunction with some large public events to reach larger audience and increase the dissemination impact. In particular, it is planned to present the project at the major communication networks and computer science regional scientific conferences like Eurocon, as well as on the conferences targeting some of the wireless sensor networking application areas (for example health or public safety related conferences). The project will organize at least two special sessions at some of these conferences and will also entice the project participants to publish their research achievements at these conferences to further promote the research area and researchers in the region.

Presentations and demos will be made at large public events like technology fairs and specialized thematic events to ensure dissemination of results to the general public. In collaboration with craft organizations (for example regional societies of physicians, SME networks) lectures and demos will be given to their members. Regional organizations of universities will be used to disseminate and promote the results of the project directly to universities in the region that are not participating in the project to entice and involve as many

as possible researchers and research centers in the region to take an active role in wireless sensor networking research.

Clustering

The project sees a great potential for cooperation with other initiatives with the same strategic objective and beyond. Because of its focus on research environment, the project will identify several initiatives.

4. Ethical Issues

The proposed project does not directly involve any ethical, legal, social or safety issues. Due to the nature of this project however, in an indirect way, the consortium will also have to deal with ethical, legal, social and safety issues relating to the research projects assisted and coached as consequence of the work foreseen in this proposal. Therefore, training measures for researchers will clearly also cover all relevant ethical, legal, social and safety issues. The consortium will endorse a project Ethical committee to clarify any doubts of their work along all activities, measurement protocols, data collection, data presentation, and data transfer.

The consortium is fully aware of the importance of ethical issues particularly in this call. Applicants confirm that the proposal does not raise sensitive ethical, legal, social or safety questions related to: human beings, human biological samples, and personal data (whether identified by name or not), genetic information, and experiments on animals.

Applicants confirm that the proposed research does not involve:

- Research activity aimed at human cloning for reproductive purposes;
- Research activity intended to modify the genetic heritage of human beings which could make such changes heritable;
- Research activity intended to create human embryos solely for the purpose of research or for the purpose of stem cell procurement, including by means of somatic cell nuclear transfer.

Data collection and evaluation will be strictly supervised whether its assessment was performed in the order of all ethical issues. Data protection of the databases will be monitored and supervised at the importing site, while just registered users could access databases. At each registration of the stakeholders a written consents will be signed to assure correct data managing. Animal tests or human embryonic stem cells will not be the subject of our project work.

Special care will be stressed on the environmental issues. We will deal with special care when working with batteries, recycle materials, and diminish travel expenses (and with it CO_2 and CO pollution) when travelling.

Still our work will involve physiological measurements on humans, which will include:

- Surface electromyography;
- Electrical twitch stimulation (1 millisecond rectangular impulses up to 60 miliampers);
- Joint torque measurement;
- Endurance tests;

The list above includes just non-invasive tests that are regularly used in medical and scientific praxis. In every test from the list above we will get Ethical approval from The national ethical committee, select and prepare participants with care, get their written consent, follow the rules from the Declaration of Helsinki, establish safety measures, assure presence of the physician, and give the participant feedback information.

4.1. Ethical Issues Table

	YES/NO	PAGE
Informed Consent		
Does the proposal involve children?	NO	
Does the proposal involve patients or persons not able to give consent?	NO	
Does the proposal involve adult healthy volunteers?	YES	
Does the proposal involve Human Genetic Material?	NO	
Does the proposal involve Human biological samples?	NO	
Does the proposal involve Human data collection?	YES	
Research on Human embryo/foetus		
Does the proposal involve Human Embryos?	NO	
Does the proposal involve Human Foetal Tissue/Cells?	NO	

Does the proposal involve Human EmbryonicStem Cells?	NO	
Privacy		
Does the proposal involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)	NO	
Does the proposal involve tracking the location or observation of people?	NO	
Research on Animals		
Does the proposal involve research on animals?	NO	
Are those animals transgenic small laboratory animals?	NO	
Are those animals transgenic farm animals?	NO	
Are those animals cloned farm animals?	NO	
Are those animals non-human primates?	NO	
Research Involving Developing Countries		
Use of local resources (genetic, animal, plant etc)	NO	
Impact on local community	NO	
Dual Use		
Research having direct military application	NO	
Research having the potential for terrorist abuse	NO	
ICT Implants		
Does the proposal involve clinical trials of ICT implants?	NO	

I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	YES	

Appendices

Appendix 1: Example Use Case Elaborated

Young patients, who are active and who had anterior cruciate ligament injury (ligamentum cruciatum anterius) and underwent reconstructive surgery, will be taken into consideration for the assessments. The deficiency of quadriceps and hamstrings will be assessed after surgical procedure. Comparing the muscle (vastus lateralis, rectus femoris, vastus medialis, biceps femoris, semi –tedinosus/membranosus, lateral and medial part of gastrocnemius) properties on both sides (injured and healthy) before and after surgery, during recovery period, we can optimize rehabilitation processes. Monitoring functional and morphological changes (muscle activation pattern, muscle fatigue, amplitude of contraction-relative force…) on each particular muscle can make a rehabilitation process more efficient and shorter. The aim of assessment would be to prevent re-injury, to reduce the cost of in-patient treatment, and to help patients resume their sport and "active life" activities when a balance of muscle strength ratio and neuromuscular properties between operated and non-operated has been attained.

Appendix 2: Hardware Details

The major purpose of the hardware subsystem is to integrate, on a board as small as possible, the following system elements (further minimization after the Proof of Concept (PoC), device is implemented and tested):

- Processing unit, with appropriate digital and analog peripherals. An example of processing unit which will be considered is one of the new Texas Instruments MSP430F5xx Series. This new flash-based family features one of the lowest active power consumptions (165 μA/MIPS) with up to 25 MIPS, 1.8V-3.6V operation. It includes an innovative Power Management Module for optimal power consumption. The device can include up to 256 KB of flash, up to 16 KB of RAM, ADC Options for 10 to 12 bits and integrates other peripherals: USB, Analog Comparator, DMA, Hardware Multiplier, RTC, USCI, 12-bit DAC. The size of the device can go down to roughly 7x7mm. Other members of the MSP430 family will be evaluated in the case if I/O capabilities are insufficient.

- Memory of the system, of the needed capacity, in the case the internal Processing Unit Memory should not be sufficient.

- Multiple sensors, of which the major one is MC-MEMS, which is a major contribution of this project.
- The units (one or more) responsible for the communications with the external world, including WSN, mobile telephony, the Internet, etc. will be used to limit the weight of the board. The communications interfaces will be limited to one or two and again, for reason of space, the BGA SoM (System on Module) will be used. For example, Meshnetics is providing a module weighing 1.3g working on the European ISM Band from 863 to 870 MHz, consuming 26mA with a 128 kBytes of on-Chip Flash Memory, 8 kBytes On-Chip RAM; all of a size 18.8 x 13.5 x 2.8 mm; the I/O of the Meshnetics module includes SPI, I2C, 1-wire, UART with CTS/RTS control, JTAG, 9 spare GPIOs (up to 25 GPIOs total), 2 spare IRQ lines, 4 ADC lines; this makes the module almost independent and it might be possible - depending on the computation load - to have the microcontroller of the module take over the functions of the processing unit. Similar modules are offered by Meshnetics for the 2.4 GHz band. Another example for a wider range wireless connectivity is the Telit BGA GPRS module whose size is 22x22x3mm, which must be carefully considered - as all long range communications solutions - as far as the power consumption is concerned.

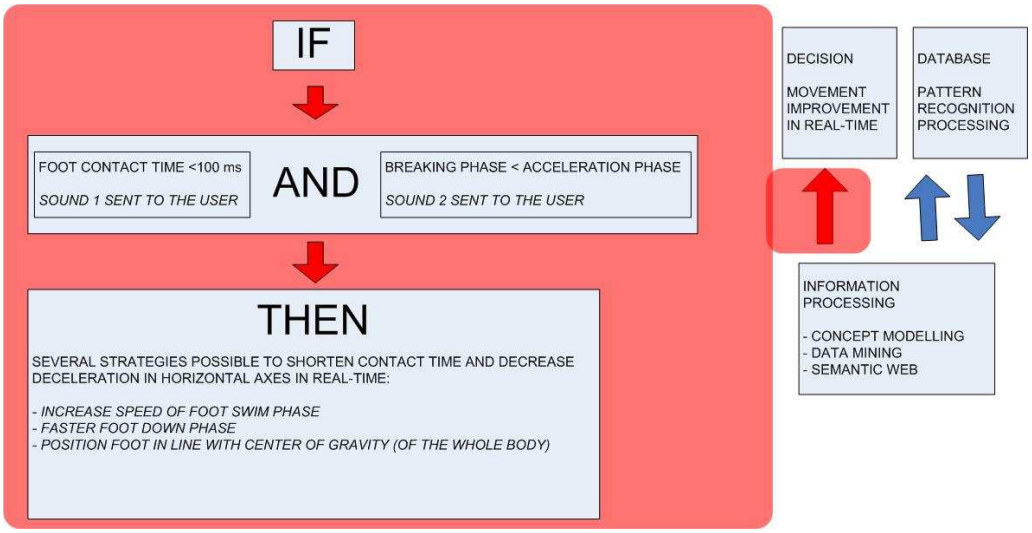
- A final example, having in mind the energy consideration, is the application of a passive low frequency (134.2 kHz) device with EEPROM and transponder interface, the TI TMS37157. If we consider an application of a sensor with a data logger, the microcontroller is connected to a battery and can wake the TMS37157 to write data into the EEPROM of the TMS37157. The data can be read out through the LF Interface of the TMS37157. This application may also be used for powering the μC out of the RF Field if a battery is not an applicable solution. The battery has to be replaced by a big enough capacitor which is used as a buffer during the LF communication.
- Last but not least important building block is the battery; the most likely technology to be used is the Lithium Polymer, for its adaptability as far as shapes are concerned. The gravimetric capacity for common LiMn2O4 cathode providing 3.7 V is about 140mAh/g. An actual battery (which takes into account packaging, etc.) is the Varta LPP 402934 E, whose dimensions are 34x30x4mm with a capacity of 330mAh and a weight of 8g. Depending on the power consumption of the system an interesting alternative is the flexible ultra thin battery Varta LFP 25 which offers a capacity of 25 mAh in 29 x 22 x 0.44 mm casing but is not rechargeable.

The first goal of integrating the system, into a board sufficiently small to be used for the vast majority of the use cases, is to be able to explore the architectural design space limiting the capital and human resources needed. The second step is to put as much as possible into a system-on-the-chip, maybe using the flip chip technology, and get the highest miniaturization.

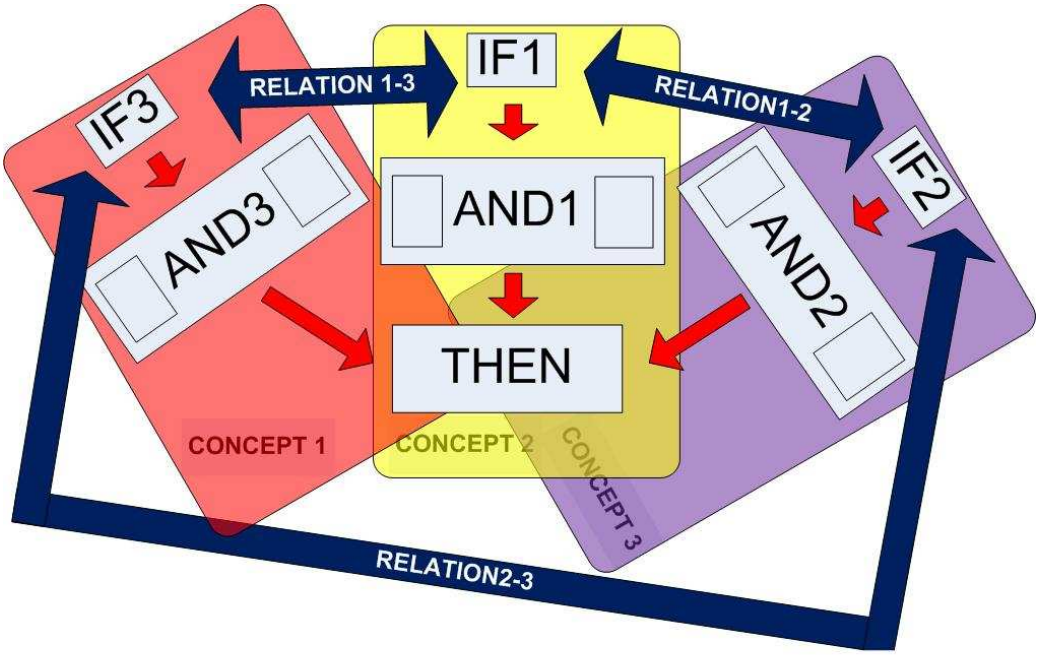
Appendix 3: Concept Modelling Details

The major purpose of the concept modelling software is to analyze input data, extract concepts to be used in data mining (to implement an expert assistant), and for semantic web

(to generate tags for XML and input for RDF). An example is elaborated here, in line with one of the use cases.



The case (concept) of the figure above is just an element (a building block, or concept) of the concept net presented in the below figure. The entire concept net, with all related concepts, will be elaborated during the course of this project.



Appendix 4: Concept Modelling Survey (by team members)

This appendix incloudes a paper submitted for possible publication in IEEE Computer, and gives an overview of the major approaches to concept modelling, which will be considered for implementation in this project.

CONCEPT MODELING FOR INFORMATION RETRIEVAL FROM KNOWLEDGE DATABASES AND THE INTERNET

SANIDA OMEROVIC, UNIVERSITY OF LJUBLJANA, SLOVENIA
SASO TOMAZIC, UNIVERSITY OF LJUBLJANA, SLOVENIA
BOZIDAR RADENKOVIC, UNIVERSITY OF BELGRADE, SERBIA
VELJKO MILUTINOVIC, UNIVERSITY OF BELGRADE, SERBIA

ABSTRACT
Recording knowledge in a common framework that would make it possible to seamlessly share global knowledge remains a central challenge for researchers. This annotated survey of the literature examines ideas about concept representation that address this challenge.

General Terms: Concepts, Knowledge, Meaning, Modeling, Ontology, Semantics

Additional Key Words and Phrases: data, relations, representation

1. INTRODUCTION

The information world that we live in today presents us with a vast amount of data stored separately in books, newspapers, radio, TV, Internet, etc., all of them increasingly digitized. Moreover, there is an exponential increase in these data day to day so that the ability of an average computer-educated person to find a specific data element or subject-related useful piece of information is decreasing rapidly. As an example of an inadequate response, most text-search engines only find matches based on keywords without regard to their various meanings [GAUCH 2002].

This research was supported by the Slovenian Research Agency under the program "Algorithms and optimization methods in telecommunications".
Authors' addresses: Sanida Omerovic, Department of Telecommunications, The University of .Ljubljana, Slovenia, sanida.omerovic@lkn1.fe.uni-lj.si; Saso Tomazic, Department of Telecommunication, The University of Ljubljana, Slovenia, saso.tomazic@fe.uni-lj.si. Bozidar Radenkovic, Department of Organisational Sciences, The University of Belgrade, boza@fon.fon.bg.ac.yu. Veljko Milutinovic, Department of Computer Science, The University of Belgrade, Serbia, vm@etf.rs;

This poses several central questions: How can one efficiently extract the desired data from a huge data source? How can a searcher find a necessary and potentially available, but

unknown, piece of knowledge that represents the answer to some question or that helps to resolve some problem? How complex must the underlying records be? It has been asserted that if the structure and function of all organisms that live or have lived on earth can be coded by triplet sequences of four nitrogenous base pairs A, G, T, and C, there is no reason for a knowledge record to be more complex than this [NOVAK 2007]. (However, pursuing the analogy, such records must be imbedded in an appropriate highly reliable processing environment such as the cell.)

To answer such key questions, it is useful to proceed from well known problems. For example, most knowledge retrieval systems in the text domain suffer from the following shortcomings:

- An inability to recognize ambiguities in the terms used in their object descriptors.
- An inability to query effectively in an uncontrolled text environment [CHUA94].

Here we follow a widespread general agreement, among most of the authors referred to in this survey, which uniform knowledge representation should be achievable by the use of ontologies, populated with concepts, as indicated in Figure 1.We extend this hypothesis to propose that the answer to efficient knowledge retrieval lies in the use of such imbedded concepts and ontologies as keys to discriminate processing.

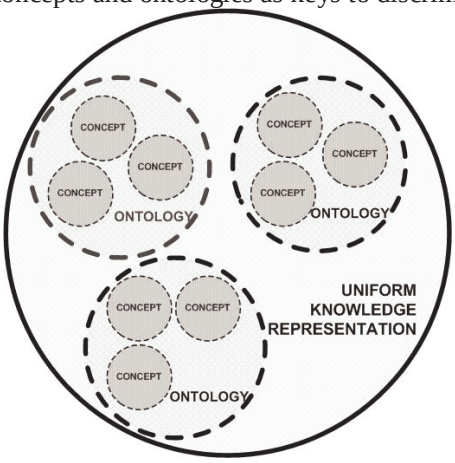


Figure 1. Uniform knowledge representation model, consisting of ontologies that are populated by concepts.

The brain remains the first and best human knowledge storage. Actually, one can observe the brain as “hardware” and our thoughts as “software” operating on such “hardware” [QUINZ 2004]. But there is still no machine that can simulate the efficient way that the human brain thinks. However, some research efforts are made in that direction. [HAWKINS 2007] created a software platform that simulates the work of brain’s neocortex (neocortex represents a thin sheet of cells which is responsible for almost all high-level thoughts and perception in human brain). On the other hand, [DEACON 1998] analyses the essence of a thinking process in language. Language is not merely a mode of communication; it is also the outward expression of an unusual mode of thought – symbolic representation. Without symbolization, the entire virtual world (telling stories about our real experiences, inventing stories about imagined ones, pondering what it will be like not to be) is out of reach – inconceivable. So, species that have not acquired the ability to communicate symbolically cannot have acquired ability to

think this way either. Of course, we are far away of understanding in total the algorithm of thinking embedded in the human brain; however, certain components are recognizable: People use concepts every day to express their thoughts, although there is no unique definition of concept or a commonly accepted agreement of what a concept is.

Nevertheless, we understand by observation how they are used in human communication to carry a circumscribed meaning (for example: a house, a dog, a car, or some more abstract idea). Still, one does not know how concepts are derived from everyday perception or learned knowledge. For every person, concept derivation appears to be unique. Because of the importance of expressing specific delimited meanings in knowledge representation, the first section of this survey is dedicated to various approaches to concepts.

Concepts alone are not enough. Grouping related concepts into ontologies has proved to be a very efficient way to capture and structure meaning within natural languages [DAML 2007]. It is a convenient means of uniting a subject, a relationship, and an object to talk about. For example, one is able to present an abstract concept of a ***person*** by means of ontologies using the Ontology Web Language OWL [OWL 2004] with datatype properties such as: firstName, lastName, gender, birthday, homeAddress, officeAddress, email, cellPhone, fax, pager, homepage, etc. Because ontologies thus enable meaning to be captured in a uniform manner, they become the essence of successful knowledge representation. Therefore, a follow up survey is dedicated to different views of ontologies [CHAN 2004][CHEN 2007][GUO 2005][HALLADAY 2005][HORROC2003][MILLIGAN2003][MOTIK 2002][PROTÉGÉ 2006][SCHRIBER 2001][WEIQI 2004].

Knowledge, as usually presented, arrives unstructured in a non-uniform manner, making it unsuitable for further joint processing (see, for example, the numerous related but incompatible computerized record systems present within every government department or business organization).

The main goal of introducing appropriate formal schemes for concept and ontology is to so structure knowledge as to make it shareable among both computers and people. As a consequence, this survey concludes with a section specifically dedicated to work on various forms of knowledge representation that are structured by concepts and ontologies [NEUHOLD 2008][NEUHOLD 2009] .

2. CONCEPTS

A concept is an entity of consciousness. We know a concept when we see one in action because it exceeds its stand-in descriptive label as a word, phrase, sentence or paragraph. It might be directly conceived or an intuited object of thought.
In general, every object, issue, idea, person, process, place, etc. can generate a concept. Embedded in language, concepts can migrate to incorporate new phenomena as they arise – leading to an evolution in their meaning over time. This malleability is both the strength and weakness of language, which lacks the precision of mathematics. (It is very apparent, for example, in every attempt to write an unambiguous law or contract.) Concept malleability is one of the underlying issues in creating a universal framework for the exchange of knowledge. Thus the goal of information computing is to unite the flexibility of language with the strict definitions of – for example – mathematics or description logics, through the

application of specific measures such as statistical weighting, neural nets, and various approaches to fuzzy logic.

2.1 Concept definition

The substance of a concept may be abstract or concrete, elementary or composite, real or fictitious. A concept can be anything about which something is thought, for example, a neural excitation induced by an object linked with an object name [SOWA 2000] (this neural excitation is illustrated in Figure 2). Concepts can describe a task, function, action, strategy, reasoning process etc [PEREZ 2002], or to be expressed in terms of other concepts [VOSS 1999]. In order to manage all such concept types they must be assigned common formal properties.

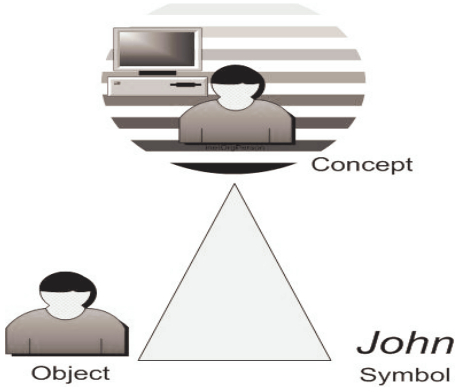


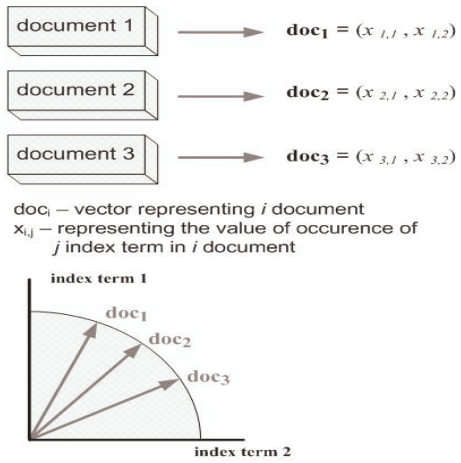
Figure 2. Concept presentation. On the lower left is an icon that resembles a person named John. On the lower right is a printed symbol that represents a person's name. The cloud on the top designates the neural excitation induced by John working at his office. This excitation is called a *concept*.

There are many view points from where one can define concepts. We have chosen to present possible concept definitions on the basis of criterion whether the concepts are implicit or explicit.

2.1.1. Implicit concept definition

If concepts can be recognized, but cannot be defined explicitly, how can a machine, for example, distinguish which words in a text are concepts, and which are not? What terms carry more "meaning" than the others? How can one make concepts recognizable, so that they are automatically extractable from any type of texts?

A Vector Space Model (VSM) [SALTON 1975] presents a possible answer to the above questions. Each document processed in VSM is in the form of a vector with its coordinates representing the values of occurrences of the index terms in that document (Figure 3a). Similarity level is measured (it might be, for example, the angle between two vectors) when the new index term is assigned to a document collection (Figure 3b.). If the similarity level decreases, a new assigned index term has a "good" discriminating property. The reverse holds for a "bad" index term.



Model is represented by a j-dimensional vector (j - number of different index terms). Documents are indexed by index terms and reside within the planes defined by index term axes. Depending on j (the number of index terms), vectors can reside in j-dimensional space within the sphere.

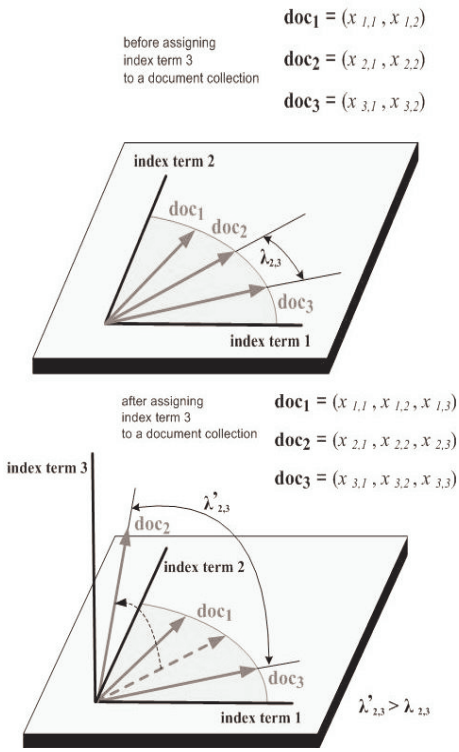


Figure 3b. Operation on a "good" discriminating term in Vector Space Model. The similarity measure is taken as the inverse function of the angle between two corresponding vector pairs (when the angle between two vectors is zero, the similarity function is at a maximum; and vice versa). Before assigning index term 3, three vector

documents reside on one plain, formed by the axes of index term 1 and index term 2. After including an index term 3 to a collection of documents, a new dimension is added to a vector space. Therefore, the coordinates of all three vectors are changed, the corresponding angles have increased, and the similarity measure is decreased.

Therefore, "good" index terms can be recognized as concepts, since they represent the smallest units of knowledge that carry the most of meaning. (enough "meaning" to decrease the similarity level between the documents when assigned to a document collection).

2.1.2. Explicit concept definition

The explicit definition of concepts can be made to depend upon the way concepts are used in such areas as simulated knowledge, description logic, and concept maps.

In [HALLADAY 2004] the atoms of Simulated Knowledge are its concepts. For a potential concept to be an atom, it must be dynamically capable of abstraction into higher entity forms, relationships and/or processes. In addition its meaning must be both syntactically and semantically interdependent, but language independent.

Description logic (a formalism for representing logic-based knowledge) is based on concepts (classes) and roles. Concepts are interpreted as sets of objects and roles as binary relations between objects [NAKABASAMI 2002].

Concept maps are mostly used for representing already organized knowledge. Here, concepts are defined as a perceived regularity among events or objects, or records of events or objects, designated by a label [NOVAK 2005]. The label for most concepts is a word or symbol (a similar idea is presented in [SOWA 2000]).

This subsection has presented several possible concept definitions with respect to simulated knowledge, description logic, and concept maps. Once so defined, the next subsection discusses issues of how concepts can be organized and thus be made predictably available for use.

2.2 Concept organization

[ZELLWEGER 2003] presents concept organization in a database as a data item with its cross-data relationships. Some data modeling techniques that aim in that direction are:

- An entity-relationship model [CHEN 2007],
- A Unified Modeling Language [UML 2007], and
- An object-role modeling [HALPIN 2007].

The above three techniques share the same basic concept structure:data items exhibit connections among different neighboring data. The essence of grasping meaning lies in the ability to assign a verbal explanation to these connections. Such a verbal explanation of the relationships between data items provides a conceptual model for the linked data items. The importance of identifying relationships between data is given in an illustrative example in [HALLADAY 2004]:

"The statement "John has an IQ of 150" explicitly describes only a very simple relationship (i.e, that John has some attribute named IQ that equals 150). However, the statement assumes a set of other implicit relationships (like IQ being an acronym for Intelligence Quotient, or that 150 is a value that precedes 151 and is proceeded by 149, or that John is a common human male name, or that an IQ equal to 150 indicates a person of above-average

intelligence, etc). However, without the context of all these relationships, the statement loses some of its meaning. In fact, meaning is the sum-total of relationships."

As discussed in [HALLADAY 2004], among the major issues in concept organization are relations. Relations can be treated as interactions between the concepts of a domain and their attributes [PEREZ 2002] (Figure 4).

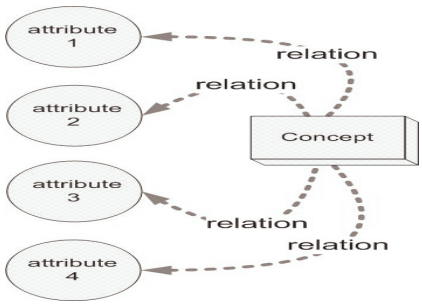


Figure 4. Relations are defined as mediators between concepts and their attributes. Attributes are classified in the following four groups, depending on their relation to a specific concept: Instance attributes - its value might be different for each instance of the concept; Class attributes - its value is attached to the concept, meaning that its value will be the same for all instances of the concept; Local attributes - same-name attributes that attach to different concepts; Global attributes - its domain is not specified and can be applied to any concept in the ontology.

Another viewpoint presenting the importance of attributes in concept organization is [Han 1996]. The Knowledge Rich Data Base KRDB consists of concepts that are presented as a set of entities and relationships. Entities together with their attributes could be defined by:

- physical data (i.e.,data relations),
- virtual data (i.e., deduction rules), or
- a mixture of physical and virtual data.

A fragment of KRDB Schema organization is presented in Figure 9.

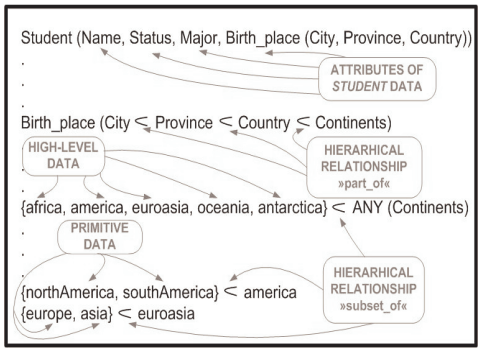


Figure 9. A fragment of a Knowledge-Rich Database Schema for *Student* as high-level data. Primitive data represents the original input data. High-level data represent a superset of primitive data and in contrast to primitive data, can contain attributes.

Possible types of hierarchical relationships between data are: *part_of, is_a, subset_of*, etc. Such semantical relationships enable query intent analysis and intelligent query answering, which are suitable further for knowledge retrieval processing.

A great deal of interface design research has been devoted to determining mechanisms for making productivity tools (e.g., word processors and drawing tools) easy to use and intuitive so that users can perform a given task more smoothly and efficiently.
Graphical, textual, and visual presentation are some of the possible mechanisms that require different concept organizations.

2.2.1. Graphical presentation
Two possible solutions to the graphical interface design are conceptual graphs and concept maps. A Conceptual Graph (CG) [SOWA 1999] contains only two kinds of nodes: concepts and conceptual relations, as presented in Figure 5. [CHEIN 1992] defined mathematically the Conceptual Graph operations.

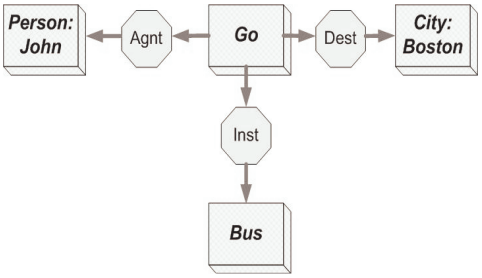


Figure 5. Conceptual Graph (CG) representing the propositional content of the English sentence: *John is going to Boston by bus.* Concepts are presented by 3-D boxes, and conceptual relations are presented by octagons. Every arc in CG must link a conceptual relation to a concept: *Go* has an *agent* (Agnt) which is a person *John*; *Go* has a *destination* (Dest) which is a city *Boston*; *Go* has an *instrument* (Inst) which is a *bus*.

Concept maps present graphical tools for organizing and representing knowledge [NOVAK 2005]. They include concepts, usually enclosed in circles or boxes of some type, and relationships between concepts indicated by a connecting line linking two concepts. Words on the line – referred to as linking words or linking phrases – specify the relationship between two concepts, as shown in Figure 6.

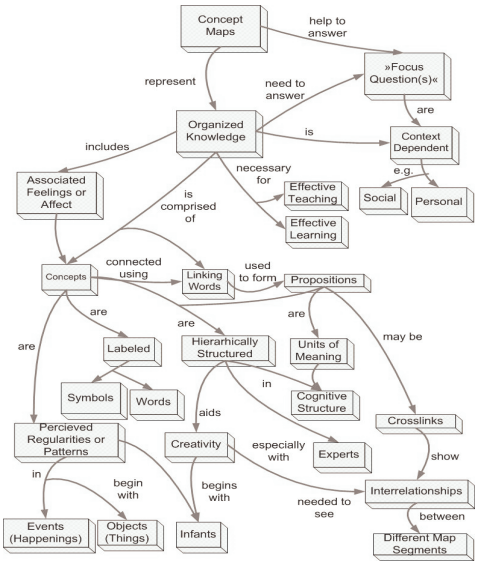


Figure 6. A concept map graphical presentation. Concepts are enclosed in 3-D boxes, and relationships between concepts are presented by arcs linking two concepts. Words on the arcs are referred to as linking words or linking phrases, specifying the relationship between the two concepts. Propositions are statements about some object or event in the universe, either naturally occurring or constructed. Propositions usually contain two or more concepts connected using linking words or phrases to form a meaningful statement usually called semantic unit, or unit of meaning. Concept maps tend to be read proceeding from the top downwards.

An example of a software package intended to search for a graph in a database of graphs is GraphGrep [GIUGNO 2007]. Within given collection of graphs and a pattern graph as the query input, GraphGrep is able to find occurrences of the input pattern in each database graph. The input pattern represents a sub graph and it can also be a tree, a path, or a node. Graphical presentation can serve as a foundation for knowledge discovery systems. SUBDUE [COOK 2007] system represents data using labeled, directed graphs.
It finds structural, relational patterns in the observed data.

2.2.2. Textual presentation

Conceptual indexing [WOODS 1997] presents one possible form of textual presentation, based on concepts. In conceptual indexing, instead of alphabetical indexing, phrases are indexed by their meaning. This is done by automatically parsing each phrase into one or more conceptual structures. Each conceptual structure represents the way the elements of the phrase are assembled to construct its meaning(s). An example of a conceptually parsed document is presented in Figure 7.

Figure 7. A fragment of Conceptual Indexing Taxonomy in a text document related to automobiles. The system first automatically parses each phrase into one or more conceptual structures. Then automatically determines when the meaning of one phrase is more general than another, given that it knows about the generality relationships among the individual elements that make up the phrase.

For example, a system can automatically determine that *car washing* is a kind of *automobile cleaning* if it has the information that a *car* is a kind of *automobile* and that *washing* is a type of *cleaning*.

One practical implementation of a conceptual indexing textual presentation is thesauri. To illustrate, the International Nuclear Information System thesaurus [INIS 1981] contains information about applications in nuclear science and technology. The record for each chunk of literature consists of three main components:

- A bibliographic description - identifying authorship, publishing, and similar ideas.
- A set of descriptors - identifying the subject content in a piece of literature.
- An abstract - summarizing the information contained in the piece of literature.

In textual presentation as discussed in [VOSS 1999] concepts are created by a user marking pieces of text in documents. Therefore, concepts are not formally defined, but one must interpret the concepts in the context of their occurrences and their use in the documents. Two simple relations in concept organization are supported by the users:

- A “comprise” relation - grouping several concepts into new concept.
- An “associated” relation - two concepts are simply seen to be closely associated, but not necessarily grouped into another concept.

2.2.3. Visual presentation

The image retrieval system based on concepts is presented in [CHUA 1994]. Every image is described with concepts, where each concept contains its descriptor and the relationships with other concepts, as shown in Figure 8.

```
SP-Chinese :==(chinese, hokkien, hakka, catonese,…);
SP-SkillJob :==(carpenter, tailor, barber, blacksmith, …);
SP-UnskillJob :==(hawker, assistant, labourer, servant);
SP-Job :== (occupation, job, SP-SkilJob, SP-UnskillJob);
SP-Occupation :==(occupation, rule, conquer, SP-Japanese);
…

Concept Occupation-of-Chinese
  Description: occupation of early Chinese immigrants in Singapore
  Component: SP-Chinese, SP-Job,…;
  Parent: Chinese-Immigrant
  Child: Rickshawmen, Merchant, Labourer,…;
  Synonym: null
  QueryProfile: null;
End of Concept;
...
```

Figure 8. The concept structure for image descriptors consists of two nodes: Semantic Primitives (SP) and Concept Nodes. SP represents the sense and use of a term or phrase in a domain. SPs are used to reduce the variability of vocabulary used by the users when issuing queries. Most important terms or phrases in the domain have their corresponding SPs to map to.

Since a term may have different meaning in different context, the mapping of some terms to their corresponding SPs may be conditional. One or more SPs constitute CN.

In summary, this subsection has presented various uniform concept organizations applied to the areas like graphical, textual, and visual presentation. The following subsection is dedicated to how concepts when organized in a uniform manner can be are in practice.

2.3 Use of Concept's for Concept-Base Search

Conceptualization – as a process to structure concepts for practical use – involves an understanding of both semantics and contexts [FUJIHARA 1997]. In text analysis, concepts can be used to ensure that only meaningful and non-ambiguous terms become text descriptors. Standard techniques based on keywords text analysis use two basic measures: the frequency of words and the distance between words. A weighted terms approach [ROBERTSON 1994] can also be introduced, where each term-document combination is given a certain weighted value (document retrieval then depends upon the corresponding input query, word frequency, word distance, and the weight values). A concept-based search is a step ahead of keyword search, and will be the main focus of this subsection related to concept use.

In concept-based search all comparable keywords are analyzed for converge to the same concept. Progress over time in achieving this [SCHATZ 1997] is traced in Figure 10. In a typical situation, the user enters a query using keywords that are recognizable in some, but not all, domains of the document collection (because different domains describe similar concepts using different terminologies). For example, if one says: "I have a doctorate" and "I am a PhD" these are two different semantic statements, but they map to the same concept. Obviously, for efficient concept-based retrieval a system must perform vocabulary switching to automatically translate terms across different domains.

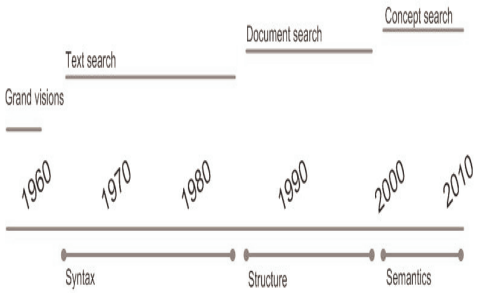


Figure 10. Rough timeline vision of the concept-searching evolution from 1960 till 2010.

Three types of concept-base search systems are presented next: KeyConcept, the Automated Generated Thesaurus Approach, and the Semantic Web.

2.3.1. KeyConcept

An example of a concept-based retrieval engine is KeyConcept [GAUCH 2002]. There, concepts are first processed by a traditional indexer using training documents under a ***tf.idf*** indexing method (Figure 11). The outputs of the ***tf.idf*** method are concepts where each concept is presented as a centroid of the training set of documents for the observed concept.

$tf.idf_{i,d} = tf_{i,d} \times idf_i$

$idf_i = \log (n/df_i)$

$tf_{i,d}$ (term frequency) = some measure of term *i* density in document *j*

idf_i (inverse document frequency) = some measure of informativeness of a term *i* in the collection of documents

df_i = the number of document that contain term *i*

n = total number of documents

Figure 11. The *tf.itf* indexing method.

The conceptual indexer of KeyConcept processes new (non training) documents by using a Vector Space Model (VSM) [SALTON 1975]. Concept-based retrieval is done by processing similarity level values obtained from VSM, words/concepts and an L-factor (entered by the user). The KeyConcept system architecture is presented in Figure 12.

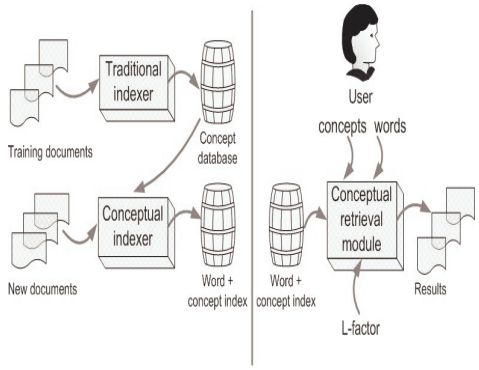


Figure 12. KeyConcept system architecture. Indexing is done by a fixed number of sample documents which are collected and processed through a Traditional indexer for each concept. The output of the indexer is a set of concepts in the Concept Database (CD) which is the essence of the Conceptual Indexer (CI). Each new document is processed through CI and the output of CI is a Word plus a Concept Index (WCI). The L-factor specifies the relative importance of concept matches to word matches and is provided by the user in a scale from 0 to 1. If L is 1, only concept matches are considered. If L is 0, only word matches are considered. When L is 0.5, concept and word matches contribute equally.

2.3.2. The Automated Generated Thesaurus Approach

Thesauri (listing of words with similar, related, or opposite meanings) can be an efficient tool for concept-based retrieval in the text domain. The Automated Generated Thesaurus Approach (AGTA) [CHEN 1999] provides an ability to fine tune what keywords a user had in mind (or should have had in mind) when proposing a particular query (the initial step in knowledge retrieval). AGTA carries this out in several phases:

- Document collection – specifying the set of documents in a specific subject domain(s) that is to serve as the thesaurus base.
- Automatic indexing of the collection of terms in the document set using an automatic indexing technique [SALTON 1975].
- Co-occurrence analysis of term frequency, inverse document frequency, and cluster analysis to assign weights to each term in a document in order to represent the term's level of the importance.
- Associative retrieval treats each term in this network-like thesaurus as an active node or neuron and the asymmetric weight between any two terms is taken as the unidirectional, weighted connection between these terms. In order to consolidate related terms and to cast out confusing outliers, the Hopfield algorithm [HOPFIELD 1982] is introduced. It first takes user-supplied terms as input patterns and then activates term neighbors (i.e., strongly associated terms), combines weights from all associated neighbors by adding collective association strengths and repeats this process until term convergence is achieved. The Hopfield algorithm also causes a damping effect in which terms farther away from the initial terms receive gradually decreasing activation weights and eventually are excluded from further processing altogether.

2.3.3. The Semantic Web

The Semantic Web [LEE 2001] represents an envisioned future evolution of the World Wide Web, where information will be human and computer understandable. It gathers together both use concepts and ontologies. As presented in Figure 13, the essence of the Semantic Web are Uniform Resource Identifier's (URI's) [W3C 2007], which can be formulated as concepts. Ontology vocabulary puts meaning into these concepts, and through XML [W3C 2007] and RDF [W3C 2007] enables a concept-based Web search. Examples of concept-based retrieval web-search engines may be found in [LINKS01].

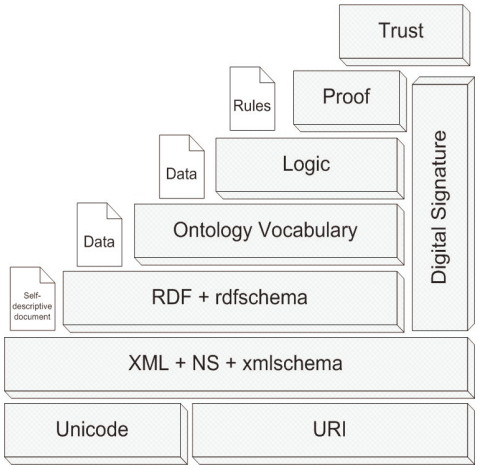


Figure 13. The Semantic Web architecture. Unicode and URI provide means for identifying objects in the SemanticWeb. eXtensible Markup Language (XML) together with the namespaces and XML schema provide syntax without semantic constraints for objects (URI's). A Resource Description Framework (RDF) triple contains three components: the subject, which is an RDF URI reference or a blank node; the predicate, which is an RDF URI reference; the object, which is an RDF URI reference, a literal or a blank node. Therefore, at this level, statements about the subject, object, and predicate are made. An ontology vocabulary defines properties and possible classes for statements built in RDF Layer. A digital signature represents small bits of code that one can use to unambiguously verify that some party wrote a certain document. The Logic Layer contains a logical reasoning mechanism in which it is possible to define logic rules. The Proof Layer executes rules defined in the Logic Layer and the Trust Layer processes security issues. Generally, Trust Layer contains a decision making mechanism to differentiate whether to trust or not to trust the given proof from the bottom layers.

Although concepts and ontologies are presented as separate layers in the Semantic Web, we are fully aware that in practice there is no clear way of distinguishing where the use of concepts stops and use of ontologies begins. Therefore, our format of "definition"; "organization", and "use" represents more the authors wish to give a formal structure to the paper, than that the separation of concepts from ontologies really allows. Still, we tried to present concepts in this form, and in the next section, ontologies will be presented using the same framework.

3. CONCLUSION

The research efforts presented here are focused on knowledge representation by ontologies populated with concepts. Concepts, ontologies, and knowledge representation are almost impossible to separate in practice, since there is no clear distinction where the use of concepts stops and use of ontologies begins in knowledge representation. Therefore, most of the research efforts presented are a combination of all tree topics.
Thus the survey can be viewed as an annotated guide to this literature.

This paper sheds more light on a selected number of different avenues leading to the same future goal of knowledge retrieval based on conceptual queries, as opposed to the current state of the art based on semantic queries. As indicated in this paper, statements "I am a PhD" and "I have a doctorate," are two different semantical entities, but they both represent the same concept. Therefore, a semantic query (e.g., focused on only one of the above two statements) will be able to retrieve only a subset of relevant knowledge, while a conceptual query (focused on both statements above, as well as all other statements supporting the same concept) would retrieve the full set of relevant knowledge. A trivial solution to the problem is, for each relevant concept, to create a case structure that includes all statements supporting that particular concept. This solution is based on exhaustive approaches, and has no practical value. Practical value lies in the many sophisticated approaches discussed in this survey paper.

The authors believe that this survey will benefit both those who want to enter the field of knowledge retrieval quickly, and those who would like to extend the state-of-art. To the best of our ability, all of the relevant work up to the present has been cited and discussed. For those who are concerned with implementation, there are examples of numerous working systems. Quite clearly there is no overarching "Killer Ap"; the results achieved so far in this domain remain both tentative and incomplete. Much work remains to be done.

ACKNOWLEDGMENTS

The authors would like to thank Charles Milligan of Sun Microsystems, USA, and Gerald O'Nions of StorageTek, France, who initiated research interest in this exciting field. Also, to Dr. Tom Lincoln, University of Southern California, USA, Dr. Roger Shannon, Duke University, USA, Dr. William Robertson, Dalhousie University, Canada, Ognjen Šćekic, B.Sc., University of Belgrade, Serbia, and Djordje Popović, B.Sc., IPSI Belgrade, Serbia, for constructive feedback on this paper.

REFERENCES

[CHAN 2004] Chan, C., "The Knowledge Modelling System and its Application," Canadian Conference on Electrical and Computer Engineering, 2-5 May 2004, pp. 1353 - 1356 Vol.3.

[CHEN 2007] Chen, P., "The Entity-Relationship Model - Toward a Unified View of Data," ACM Press, ACM Transactions on Database Systems, pp. 9-36 Vol. 1, Issue 1.

[CHEN99] Chen, H., Houston, A., Sewell, R., Schatz, B., "Internet Browsing and Searching: User Evaluations of Category and Concept Space Techniques," Journal of the American Society for Information Science, 6 Jan 1999, pp.582 – 603 Vol. 49, Issue 7.

[CHUA 1994]Chua, T., Pung, H., Lu, G., Jong, H., "A Concept-based Image Retrieval System," Proceedings of the Twenty- Seventh Hawaii International Conference on System Sciences,. Vol. III: Information Systems: Decision Support and Knowledge-Based Systems, Wailea, Hawaii, USA, 4-7 Jan. 1994, pp. 590-598.

[COOK 2007]Cook, D.,"SUBDUE Graph Based Knowledge Discovery,"http://www.uta.edu/ra/real/editprofile.php?pid=176&onlyview=1

[DAML 2007]DAML ontologies, DARPA, USA, www.daml.org/ontologies

[DEACON 1998]Deacon, T., "The Symbolic Species – the Co-evolution of Language and the Brain," W.W.Northon & Company, USA, 1998.

[FUJIHARA 1997] Fujihara, H., Simmons, D., "Knowledge Conceptualization Tool," IEEE Transactions on Knowledge and Data Engineering archive, March 1997, pp. 209 – 220 Vol. 9, Issue 2.

[GAUCH 2002] Gauch, S., Madrid, J., Induri, S., Ravindran, D., Chadalavada, S., "KeyConcept: A conceptual Search Engine,"Information and Telecommunication Technology Center, Technical Report: ITTC-FY2004-TR-8646-37, University of Kansas, USA, 2002.

[GIUGNO 2007] Giugno, R., Sasha, D., "GraphGrep", http://alpha.dmi.unict.it/~graphgrep/index.html

[GUO 2005] Guo, P., Fan, L., Ye, L., Cao, J., "An Algorithm for Knowledge Integration and Refinement," Proceedings of the Fourth International Conference on Machine Learning and Cybernetics, Guangzhou, 18-21 August 2005.

[HALLADAY 04] Halladay, S., Milligan, C., "The Application of Network Science Principles to Knowledge Simulation," Proceedings of the 37th Annual Hawaii International Conference on System Sciences, Hawaii, 5-8 Jan. 2004.

[HALLADAY 05] Halladay, S., Milligan, C., "Knowledge VS.Intelligence, IPSI Belgrade, Proceedings of the IPSI-2005 Montengro conference, Sveti Stefan, Montenegro, 2005.

[HALPIN 2007]Halpin, T., Object Role Modeling, Neumont University, USA, http://www.orm.net/

[HAN 1996] Han, J., Huang, Y., Cercone, N., Fu, Y., "Intelligent Query Answering by Knowledge Discovery Techniques," IEEE Transactions on Knowledge and Data Engineering, June 1996, pp. 373-390 Vol. 8, No. 3.

[HAWKINS 2007] Hawkins, J., "Learn Like a Human," IEEE Spectrum on-line, April 2007.

[HOPFIELD 1982] Hopfield, J., "Neural networks and physical systems with emergent collective computational abilities," Proceedings of the National Academy of Sciences of the United States of America, USA, 15 April 1982, Vol. 79, No. 8.

[HORROC 2003] Horroc, I., "Fast Classification of Terminologies," School of Computer Science, University of Manchester, UK, 2003.

[INIS 1981] INIS Thesauri, International Atomic Energy Agency (IAEA), Vienna, Austria, Januar 1981

[LINKS 01] www.vivismo.com, www.grokker.com, www.clusty.com, etc

[MILLIGAN 2003] Milligan, C., Halladay, S., "The Realities and Facilities Related to Knowledge Representation," IPSI Belgrade, Proceedings of the IPSI-2003 Montengro conference, Sveti Stefan, Montenegro, 2003.

[MOTIK 2002] Motik, B., Maedche, A., Volz, R., "A Conceptual Modeling Approach for Semantic-driven Enterprise Applications," Springer Berlin / Heidelberg, Book on the Move to Meaningful Internet Systems 2002: CoopIS, DOA, and ODBASE: Confederated International Conferences CoopIS, DOA, and ODBASE 2002. Proceedings 2002 Vol. 2519P.

[NAKABASAMI 2002] Nakabasami, C., "An Inductive Approach to Assertional Minning for Web Ontology Revision," International Semantic Web Conference (ISWC2002), Sardinia, Italy, 9-12 June 2002.

[NEUHOLD 2008] Neuhold, E., Vujovic, I., Milutinovic, V., "Tutorial on Datamining," Session Dedicated to Nobel Laureate Martin Pearl, VIPSI-2009 BELGRADE and World University Presidents Conference, April 2009.

[NEUHOLD 2009] Neuhold, E., Vujovic, I., Milutinovic, V., "Tutorial on Semantic Web," Session Dedicated to Nobel Laureate Jerome Friedman, VIPSI-2008 BELGRADE and the 200YR Annual Celebration of Belgrade University, September 2008.

[NOVAK 2005] Novak, J., Cañas, A., "The Theory of Underlying Concept Maps and How to Construct them," Technical ReportFlorida Institute for Human and Machine Cognition CmapTools 2006-01, USA, 2005.

[OWL 2004] OWL, Web Ontology Working Group, 2004, http://www.w3.org/2004/OWL/

[PEREZ 2002] Gomez-Perez,A.,Corcho, O., "Ontology Languages for the Semantic Web," IEEE, Intelligent Systems, Jan-Feb 2002, pp. 54-60 Vol.17, Issue 1.

[PROTEGE 2006] Protégé, Stanford University, USA,2006,http://protege.cim3.net/cgi-bin/wiki.pl?ProtegeOntologiesLibrary.

[QUINZ 2004] Quinz, D., Acacetus Inc, Canada, private communication, 20.9.2004

[ROBERTSON 1994] Robertson, S., Jones, K., "Simple, Proven Approaches to Text Retrieval," Technical report TR356, Cambridge University Computer Laboratory, UK, 1994.

[SALTON 1975] Salton, G., Wong, A., "A Vector Space Model for Automatic Indexing," Communications of the ACM, 1975, pp. 613 - 620 Vol. 18, Issue 11.

[SCHATZ 1997] Schatz, B., "Information Retrieval in Digital Libraries: Bringing Search to the Net," Science, 17 January 1997 pp. 327-334 Vol. 275.

[SCHREIBER 2001] Schreiber, A., Dubbeldam, B., Wielemaker, J., Wielinga, B.,"Ontology-Based Photo Annotation," IEEE, Intelligent Systems, May-Jun 2001, pp. 66- 74 Vol. 16, Issue 3.

[SOWA 2000] Sowa, J., "Ontology, Metadata, and Semiotics," Proceedings of the Linguistic on Conceptual Structures: Logical Linguistic and Computational Issues table of contents, 2000, pp. 55 – 81.

[SOWA 1999] Sowa, J., Tepfenhart, W., Cyre, W. "Conceptual graphs: draft proposed American National Standard,". Springer-Verlag, Berlin, Germany, Lecture Notes in Computer Science, 1999, pp. 1-65.

[UML 2007] Unified Modeling Language, Object Management Group, http://www.uml.org/

[VOSS 1999] Voss, A., Nakata, K., Juhnke, M., "Concepts as Knowledge Handles in Collaborative Document Management," International Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises, Stanford, USA, 16-18 June 1999, pp. 245-252.

[WEIQI 2004] WeiQi, C., JuanZi, L., KeHong, W., "CAKE: The Intelligent Knowledge Modeling Web Services for Semantic Web," The 8th International Conference on Computer Supported Cooperative Work in Design Proceedings 26-28 May 2004 Xiamen, China, pp. 209-216.

Appendix 5: Summary of participant involvement and levels of effort

PARTNERS		WP0	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	ΣWP (%/MM)
TMG	%	3	3	3	3	3	3	4	2	2	26
	MM	15 (L)	15 (L)	15	15	15	15	20	10	10	130
BGDUNI	%	0	2	3	2	1	1	2	2	2	15
	MM	0	20	30 (L)	20	10	10 (L)	20	20	20	150
FERRARA	%	1	1	6	2	3	1	3	3	2	22
	MM	5	5	30	10	15 (L)	5	15	15	10	110
MEDIA	%	0	0	0	0	0	0	0	2	3	5
	MM	0	0	0	0	0	0	0	10 (L)	15	25
ORTO	%	0	0	0	0	0	0	3	1	1	5
	MM	0	0	0	0	0	0	30 (L)	10	10	50
KOPUNI	%	0	0	0	0	0	0	3	0	0	3
	MM	0	0	0	0	0	0	15	0	0	15
SPACE	%	1	1	1	1	2	1	1	1	1	10
	MM	5	5	5	5	10	5	5	5	5 (L)	50
FE	%	0	0	1	4	1	0	0	0	0	6
	MM	0	0	5	20 (L)	5	0	0	0	0	30
FRI	%	0	1	0	0	2	0	0	0	0	3
	MM	0	5	0	0	10	0	0	0	0	15
BSC	%	2	0	0	0	0	0	3	0	0	5
	MM	10	0	0	0	0	0	15	0	0	25
	Σ%	7	8	14	12	12	6	19	11	11	100
	ΣMM	35	50	85	70	65	35	120	70	70	600

Legend:

L = Leadership of WP'sWP = Work PackageMM = Men/Month M1 = Month No.1HR = Human Resources