SIXTH FRAMEWORK PROGRAMME
PRIORITY 2.3.4.1
Future and Emerging Technologies

Contract for:

COORDINATION ACTION

Annex I - "Description of Work"

Project acronym: **NiSIS**
Project full title: **Nature-inspired Smart Information Systems**
Proposal/Contract no.: **13569**
Related to other Contract no.:

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Start date of contract:

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1. Project Summary

Nature-**i**nspired **S**mart **I**nformation **S**ystems
NiSIS

Strategic objectives addressed: 2.3.4.1. FET Open

NiSIS is a European Project under the Co-ordinated Action (CA) scheme with the following overall mission aims:

- to co-ordinate multi-disciplinary studies and research endeavours into the development and utilisation of intelligent paradigms in advanced information systems design.
- to extend investigations into emerging new areas inspired by nature, both at biological (i.e. micro) and behavioural (i.e. macro) levels for visionary concepts of information processing and architectures.

The Co-ordination action will comprise four parts aiming to interconnect different disciplines and activities in an effective scheme:

A) The core of the project is a set of three Focus Groups which are to deliver the scientific and technological contributions of the programme. There are Focus Groups on: Nature-inspired Data Technology, Nature-inspired Networks, and Nature-inspired Systems Modelling, Optimisation and Control.

B) Technology Transfer will take results from the 3 Focus Groups in terms of technological concepts and algorithms, but also contribute challenges via Competitive Workshops concentrating on benchmarking situations taken from real-life relating to IST situations. Training and Education will give added-value in terms of cross-disciplinary instruction and motivation etc. for an upcoming generation of young researchers. Each of these activities will be present proactively in NiSIS as well as open to the wider community.

C) The overall integration of the Project will be overseen by an ITB (Integrated Technology Board), with participants from all of the above groups and committees, thus providing both “pulling” technology from the life sciences and “driving” the technology into IST via technical co-ordination of the project and a comprehensively designed Roadmap.

D) The co-ordination of NiSIS will be achieved via the management component provided by the ELITE Foundation. Apart from the overall co-ordination, assessment of the Project and project activities supervision, the Co-ordinator will seek collaboration between the participating multidisciplinary Partners as well as new potential partners enhancing the research opportunities of NiSIS. The Service Centre of NiSIS will support all the activities and will also develop and administrate a dedicated web-site as part of an information infrastructure for all interested institutions.

2. Project objectives and state of the art

2.1 Introduction: The challenge

In recent years, biological and natural processes have been influencing the methodologies in science and technology in an increasing manner. Thus, the work of Wiener in cybernetics was heavily influenced by feedback control processes observable in biological systems. McCulloch and Pitts' description of the artificial neuron was seeded from mathematical biology and electronics. Watson and Crick's description of the DNA molecule and the subsequent immense strides now being made in genomics offer similar possibilities for advances in IST. Also, there is a deepening knowledge of natural immunological systems which are able to recognise and eliminate foreign bodies, thus providing an obvious paradigm for vital future security methodologies for advanced IST networks.

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- To co-ordinate multi-disciplinary studies and research endeavours into the development and utilisation of intelligent paradigms in advanced information systems design.

Information systems manipulate and transmit/receive data in such a manner as to convey information and knowledge between humans and machines. They have across-scale magnitudes of components and complexity in size and behaviour. Intelligent (Information) Systems are able to learn and adapt on-line by either updating parameters or structures of the system in a stable and reliable manner.

To extend investigations into emerging new areas inspired by nature, both at biological (i.e. micro) and behavioural (i.e. macro) levels for visionary concepts of information processing and architectures. Under this mission statement, the main objectives of NiSIS (which are detailed in the work packages in Section B.6) are to:

- Encourage cross-disciplinary team-based thinking to cross-fertilise engineering and life science understanding into advanced inter-operable systems.
- Progress the theme of adaptivity beyond curiosity and basic earlier engineering concepts and theory, via the spur of naturally-occurring phenomena and self-emergent systems.
- Elaborate the themes of hierarchy, modularity, redundancy, learning capacity etc in pursuit of greater robustness and reliability against uncertainties, time-variations and fault conditions for large information systems.
- Incorporate the large body of knowledge on systems dynamics, modelling and identification/estimation into hybrid structures based on intelligent paradigms.
- Develop a Taxonomy and Strategic Roadmap to describe the state-of-the-art knowledge in the different disciplines about intelligent systems and to signpost a future for integration of deeper nature-inspired concepts into smart devices and systems. This aims to prepare for long term goals leading beyond FP6.
- Provide training and education across the relevant disciplines via workshops, symposia, Best Practice Guidelines etc.
- Foster Technology Transfer via competitive team-based feasibility Workshops on realistic benchmarking problems.
- Co-ordinate the Project with a management structure which fosters cross-disciplinary endeavours via Focus Groups, Task Forces on innovative concepts , Annual symposia etc.
- Grow a new set of teams/groups via recruitment of new partners/partners steadily over 3 years, with a target of about 100 actively participating members.
- Encourage promising young researchers in the field, spin-off ventures and SME via interchange of students and researchers using Web-based material and short Schools providing expertise transfer.
- Establish links with other scientific projects and organisations, such as EU Networks of Excellence, which are working in the generic field of intelligent systems, via Web-site data and information communication.

The success of the activities undertaken for achieving these goals can be assessed by:

1. Number of reports and case studies, state-of-the-art surveys and their European-wide distribution.
2. Increase in the number of significant research proposals in the area of NiSIS, specially if they are initiated by NiSIS partners.
3. Increase in the number of scientific reports and papers in the area of combined applications of nature-inspired intelligent technologies and information systems.

4. Initiated events and training activities. The use of training products initiated by partners in WWW. The number of successful cases of scientific mobility exchange.
5. Number and quality of research projects/task forces initiated by NiSIS in order to tackle the research challenges of designing emerging information systems.

2.2 Nature-inspired R&D in IST

NiSIS will stimulate the emergence of new research and application themes/dimensions inspired by current rapid progress in the understanding of natural living systems. Impressive innovative techniques in microbiology during recent decades have given rise to huge data sets at genetic levels. These contain information of underlying architectures with probabilistic features, and the data have vast uncertainties caused by big noise levels. This challenge is beginning to spawn new methods of exploration and exploitation in the area of data-mining. Incredible advances in measurement and monitoring techniques sparked off by physics and chemistry have led to exciting and unprecedented understanding, but this knowledge needs a new spin-off into large information systems design and implementation. At a macroscopic level, the behaviour of animal colonies (e.g. bees and ants) provide insight into structures/societies which possess fault and damage tolerance. This is providing concepts in systems security, both for docile and hostile environments. Also, such paradigms are becoming important for large scale optimisation using principles of swarm intelligence, such as bird migratory flocking. These algorithms are better than Genetic Algorithms (GA) since they are much faster for multi-objective optimisation and are simpler to understand being based on straightforward motion vectors and dynamics.

NiSIS will foster the transfer of technological advances driven by concepts from nature/biology including:

- Advances in structural genomics which are useful for IST networking ideas. The mapping of genes to proteins and proteins to genes has demonstrated the one-to-many and many-to-one characteristics of naturally-occurring organisms. This promotes the need to study non-causal but mutually-interacting structures which will go beyond the multi-agent technologies of today. Innovative work in this field is just beginning. Included in these structural studies must go the ability of natural systems to restructure themselves, not just to adjust their parameters.
- Functional genomics are demanding new ideas in hybrid systems arising from heterogeneous and inconsistent origins of disparate databases together with their design. This requires major innovations in the visualisation of high-dimensional data, for which current computational methods are woefully inadequate. Biologists have much to contribute here since they are primarily graphically-driven and used to analysis at these levels.
- The modelling of complete cell structures is using concepts of modularity and hierarchy which go significantly beyond the known current processes of engineering hierarchical hardware and software systems of today. Whole new ontology's will become necessary driven by studies into cellular mechanisms.
- Drug design has spawned new techniques for vast combinatorial searches in imprecise data bases, which are useful for optimisation and what-if virtual designs and simulations.
- Methodological advances are needed in the life sciences and are being developed in both medical informatics and biological modelling. This is particularly important because of the large uncertainties in living systems which require probabilistic models beyond those encountered in classical engineering and current information systems. This is exacerbated by endemic nonlinearity and the need for confidence bands in modelling and prediction studies. This is clearly relevant for Web-based technologies and GRID-enablement together with future architectures.
- Basic physical particles interact to form molecules, which interact to form living organisms, which organise themselves to form ecological systems, etc. As the complexity of behaviour and the types of interactions increases, one sees the emergence of social behaviour, economic systems and cultural elements. The properties and the characteristics of these emergent systems are so vastly different that each is being studied in different scientific disciplines, which develop their own approaches, solution methods and conceptualisation. The design, control and operation of large-scale information systems will benefit from the insights developed in cross-disciplinary studies in this area.

2.3 Scope of the project

To achieve the above mentioned objectives it is necessary to recognise and incorporate the vast but fragmented knowledge about nature-inspired processes, information systems and behaviour of living systems as well as systems in the process industry. To integrate and manage this knowledge towards the engineering of IST systems it will be necessary to move the well-established engineering design principles developed over many decades into areas which involve *structure, function* and *behaviour* which are significantly beyond the current mind-set of designers of modern high technology artefacts. It must learn from

metaphors within the disciplines of the life and physical sciences, mathematical theory and social and economic systems of our modern world.

In terms of *structure*, the migration from conventional to nature-inspired intelligent systems will involve different morphologies to those of conventional uni-directional connectivity and modularity which give uniquely describable performance. Standard ideas of aggregation and decomposition must be replaced with flexible decentralised paradigms. Reconfigurable structures are needed to attend to the needs of self-repair/healing.

At a *functional* level, the well-understood engineering cycle must adjust from its linear sequencing of specification to self-goal-setting under constraints, from planning to self-forecasting, from design to "rule-driven" self-organisation, from analysis to self-understanding, from implementation to self-realisation, from observation to self-monitoring and from control to self-decision-making/autonomy.

In the area of *behaviour*, we must move from fixed parameter models to those which embrace adaptive algorithmic descriptions. Behaviour itself will change from monotypical predictable modes to those which are multitypical, competitive, co-operative, collaborative, deceptive and goal-driven forms of behaviour. This will require self-aware IT networks, capable of automatic reconfiguration of topology, and self-organising information repositories forming local clusters of unstructured data. The ultimate aim is for self-designing and self-maintaining software IT systems.

All of the above require an *integrated* approach to system design and implementation. Engineering has vast experience in modelling of the classical sort based on dynamic equations. This knowledge needs integration into hybrid intelligent structures based on naturally-occurring structures and dynamics. They need synergetic coupling, both via empirical design and theoretical analysis.

At the core of the project is a set of 3 major research areas via which the partners will deliver the scientific and technological contributions to the programme. All the participating groups will channel their activities into achieving the Potential Impact outlined in Section 2. The 3 research areas are :

1. Nature-inspired Data Technology (NiDT)

The huge advances in genomics in terms of data gathering is outpacing similar challenges in IST, both of which will demand a step-increase in our ability to manage vast amounts of data. Thus, this area addresses the theme of very large data sets requiring new methods of data-mining, information processing, knowledge discovery and decision-support. It has to consider disparate data sets (e.g. numeric versus symbolic; quantitative versus qualitative; continuous versus discrete). The drivers will be advances in biological genetic code measurements and new computer science techniques to cope with the vast new structural information being gathered currently in living systems.

Furthermore, there is a growing understanding in business/economics that individual decision-making behaviour in the face of uncertain and partial information (e.g. the behaviour of an intelligent agent as opposed to simple rational behaviour) has a significant impact in explaining the characteristics of these systems. Natural intelligence can be used to study and design hybrid multi-agent systems that can exhibit such rich behaviour. Intelligent agents adapt and learn from their interactions and past information to develop rules and strategies that will allow them to achieve their goals and their intentions. The intelligence of agents is attributed to their adaptation, learning and strategy forming capability. Additionally, intelligent agents can also be characterised by their internal social norms, behavioural rules and knowledge acquired from experience. Various techniques from artificial and computational intelligence can be used to capture the intelligent behaviour of the agents. Neural networks, evolutionary algorithms, Fuzzy systems, cellular automata and swarm intelligence, or their combination in hybrid systems are the most popular. The study of such agents in smart information systems is an interesting and most relevant research topic.

2. Nature-inspired Networks (NiN)

Research in bio-inspired paradigms include artificial brains and evolvable hardware systems which are examples of novel approaches for the design of fault-tolerant networks. Thus, knowledge is distributed throughout multiple processing elements, inspired by multi-cellular biological structures. One such paradigm is the POE model for hardware design. The POE concept maps evolvable hardware over 3 inter-related dimensions .The P-dimension (Phylogeny) embraces the evolution of species when genes are passed from one generation to the next i.e. species adaptation. The O-dimension (Ontology) refers to the development/change-of-state of multi-cellular organisms during their embryonic phase. Because of the principle of cellular division and differentiation this domain is adaptable to digital systems. The E-dimension (Epigenesis) represents the adaptivity of individuals to changes in the environment through learning. The POE structure provides a nature-inspired research flow for the creation of self-reproducing, self-healing evolvable systems using multi-array networks. Embryonics (embryology electronics) belongs to the O-dimension. Immunotronics belongs to the E-dimension, where the basic unit is the artificial cell which demonstrates the bio-inspired features of reduced memory and DNA-repair function. Also, developmental biology, itself, is at exciting research frontiers of amazing structural growth (e.g. in butterfly and fruitfly wing development), comprising not only static pattern development but also internal dynamics.

Further, co-operating colonies of bees and ants give examples of hyper-intelligence. Another example is the BT “fly-phones” concept for frequency allocation in mobile phone networks which is based on cell differentiation in the fruit-fly (drosophila).

In particular, business/economic systems can be viewed as networks of information processing entities that pursue their own goals and interact with one another in a multitude of flexible ways. Economic theory has developed a number of methods for modelling such networks and analysing the desirable properties of their operation. Theories regarding the workings of markets, microeconomic systems, influence of adverse information effects and the influence of transaction cost effects can be given as examples. These results could be used to allocate resources efficiently and effectively in complex information systems, to design frameworks in which such information systems can operate and to guide the emergent properties of complex information systems. Already artificial markets are being designed investigated for optimisation in decentralised network systems (e.g. optimal scheduling in IT systems for supply chain management) and information sharing (artificial information markets for autonomous agents). Thus, input from business/economics is important for smart information systems.

3. Nature-inspired Systems Modelling, Optimisation and Control (NiMOC)

In past decades, systems theory has been developed for utilisation in classical engineering. Many techniques have been produced for model representation and identification, parameter optimisation and feedback control analysis. These are now being exploited and extended within Systems Biology research. Future extensions in these fields should provide the drivers for exploitation of these concepts into smart IT systems.

It is intended within this NiSIS research area to bring IST together with the still-emerging field of Systems Biology, as a specific focused area of application of systems modelling, optimisation and control. In the life sciences today a holistic view to understand how an organism works is increasingly required and dealt with by the emerging multi-disciplinary and multi-laboratory concept of Systems Biology. Such a holistic view supported by systems theory becomes more and more realistic due to the availability of ‘post-genomic’ technologies that generate huge amounts of highly specific, experimental data in genomics, transcriptomics, proteomics, metabolomics, cytomics and physiomics. The challenge is to understand and model the structure and the dynamics of interactions between different components, e.g. within gene regulatory networks, signal transduction networks and metabolic networks. In this context it is a challenge for instance to develop techniques that extract hypotheses about interaction networks from experimental data in genomics, transcriptomics and proteomics as well as metabolomics and cytomics and to subject these hypotheses to Systems Modelling that can then, in the next step, be used for experimental design and validation. In order to meet these major challenges in the life sciences and to keep track of the remarkable progress in molecular and cellular biology, Smart Information Systems are required as a technology that is not only valuable to the life sciences but also to the social sciences, computer sciences and physics. In a wider sense, Information Technology will benefit from the combination of Systems Modelling and Systems Biology by elucidating structures of nature that may serve in man-made information technology systems, an approach perhaps best described as *IT Bionics*. Systems Biology is beginning to probe mechanistic models of untold complexity. Techniques are being developed for probing such biological systems via genetic engineering in totally novel ways which may well be relevant for the analysis and design of smart IT systems.

3. Participants List

Role	No	Name	Short Name	Country	Date enter project	Date exit project
C	1	ELITE European Laboratory for Intelligent Techniques Engineering	ELITE	Germany	1	36
CR	2	The University of Sheffield, Department of Automatic Control & Systems Engineering	USFD	United Kingdom	1	36
CR	3	Bournemouth University Higher Education Corporation, School of Design, Engineering and Computing	Bournemouth Univers	United Kingdom	1	36
CR	4	Erasmus Universiteit Rotterdam, School of Economics, Department of Computer Science	EUR	Netherlands	1	36
CR	5	Steinbeis GmbH & Co für Technologietransfer	TZMI	Germany	1	36
CR	7	The University of Bristol, Artificial Intelligence Group, Dep. of Engineering Mathematics	UOB	United Kingdom	1	36
CR	8	University of Nottingham, School of Computer Science and IT	UNOTT	United Kingdom	1	36
CR	9	University of Oulu, Control Engineering Laboratory	UOULU	Finland	1	36
CR	11	Danmarks Tekniske Universitet, Department of Automation	DTU	Denmark	1	36
CR	12	Hans-Knöll-Institute for Natural Products Research, Dep. for Applied Microbiology	Hans-Knoell	Germany	1	36
CR	13	Universiteit Maastricht, Dept. of Mathematics, Faculty of General Sciences	UM	Netherlands	1	36
CR	15	BioControl Jena GmbH	BCJ	Germany	1	36
CR	16	University of the Aegean, Financial and Management Engineering	University of Aegean	Greece	1	36
CR	17	Universita degli Studi di Genova, DIBE-Department of Biophysical and Electronic Engineering	UG	Italy	1	36
CR	18	British Telecommunications plc, Research and Venturing, Future Technologies Group	BT	United Kingdom	1	36
CR	19	University of Twente, Centre for Telematics and Information Technology	MESA+	Netherlands	1	36
CR	20	Schott AG, Dept. of Mathematical Simulation and Optimisation	Schott	Germany	1	36
CR	21	Czech Technical University in Prague, Dep. of Cybernetics, Faculty of Electrical Engineering	CTU	Czech	1	36
CR	22	Universidad Politecnica de Madrid, Department of Artificial Intelligence	UPM	Spain	1	36
CR	27	Université Pierre et Marie Curie Paris VI Laboratoire Informatique de Paris - LIP 6	UPMC	France	1	36
CR	28	University of Natural Resources & Applied Life Sciences, Department of Biotechnology	BOKU	Austria	1	36
CR	29	Otto-von-Guericke Universität Magdeburg, Institut für Mechanik	UMAG	Germany	1	36
CR	30	Faculdade de Ciencias da Universidade de Porto	FCUP	Portugal	1	36
CR	31	Norwegian University of Life Sciences	UMB	Norway	1	36

In the above table an overview of the partners is given. The following table shows the multidisciplinarity of the founding partners of the consortium. In addition it is indicated which type the institution has (4 industrial partners) and which gender the leading person of the partner has (4 women are leaders). Each Partner is assigned in minimum to one of the committees of the project. This assignment is shown in the last column. The committee leader is marked in bold.

No	Short Name	Discipline	Type	Leader	Gender	Committee
1	ELITE	Business/Economics	R	Lieven	m	ITB, TTE
2	USFD	Biology	U	Linkens	m	**ITB**, NiMOC
3	Bournemouth Univers	Computer Science	U	Gabrys	m	NiDT
4	EUR	Business/Economics	U	Kaymak	m	NiN
5	TZMI	Engineering	R	Jovanovic	m	TTE
7	UOB	Computer Science	U	Martin	m	**NiN**
8	UNOTT	Computer Science	U	Garibaldi	m	NiMOC
9	UOULU	Engineering	U	Leiviskä	m	ITB, NiMOC
11	DTU	Engineering	U	Jantzen	m	TTE
12	Hans-Knoell	Biology	R	Guthke	m	ITB, **NiMOC**
13	UM	Mathematics	U	Westra	m	NiMOC
15	BCJ	Biology	I	Pfaff	m	NiMOC
16	University of Aegean	Business/Economics	U	Dounias	m	NiN
17	UG	Engineering	U	Anguita	m	ITB, **NiDT**
18	BT	Computer Science	I	Tateson	m	NiDT
19	MESA+	Computer Science	U	Poel	m	TTE
20	SCHOTT	Mathematics	I	Lankers	f	NiDT
21	CTU	Life Science	U	Lhotska	f	TTE
22	UPM	Computer Science	U	Hernandez	f	NiN
27	UPMC	Mathematics	U	Detyniecki	m	NiDT
28	BOKU	Life Science	U	Bayer	m	NiMOC
29	UMAG	Engineering	U	Strackeljan	m	**TTE**
30	FCUP	Mathematics	U	Feio Mendonca	f	NiMOC
31	UMB	Biology	U	Erik Plahte	M	NiN

Please find the profiles of all participants attached to the Annex I as Appendix 1.

4. Relevance to the Objectives of FET Open

The FET programme complements the IST targets from a future-oriented and explorative point of view. Its aim is to contribute to the safeguarding and strengthening of Europe's competitive position also in those sectors that are currently not clearly outlined and marked by considerable technological and economic uncertainty in terms of their development risk. In concrete terms, it is also about supporting long-term projects with a high insecurity factor.

Without doubt the economic potential of nature-inspired IST systems - and consequently of intelligent, adaptive systems in industry and research - is enormous and in many cases impossible to predict in detail. Scientific and technological progress shows no indication of slowing down: there are no limitations in sight in the sectors of microsystems technology, sensorics methods of computational intelligence or software technology. Consequently the development in the information intensive system area is still in its infancy.

A considerable number of universities and private industry research laboratories are involved in systematic R&D projects that are of significance to nature-inspired information systems. It is obvious, however, that these projects are not sufficiently consolidated e.g. at conferences, workshops and symposiums. Further and extensive efforts will have to be undertaken to support co-operation and to synchronise research projects. In concrete terms, this means that projects will be co-ordinated so that the reciprocal information flow is speeded up and that a higher degree of creativity and scientific dynamics is generated through intensive dialogues.

Extensive information about the perspectives of equivalent development in the US and Japan is available, but it has not been compiled systematically. In this context, the co-ordinated approach suggested here will be a small contribution to the creation of a stronger counter-balance and the initiation of significant impulses for technological breakthroughs.

There have been frequent complaints about a lack of open-mindedness among young people towards technological issues, as this factor has always been and continues to be essential for our society's continued economic success. One intention of the co-ordinated action approach is to foster the enthusiasm of researchers and students about nature-inspired system in IST.

Obviously, to achieve the objectives of the action we strongly believe in the necessity of proper dissemination programs for spreading nature-inspired approaches with high potential impact into the whole domain of practitioners. This is one of the main aims of the NiSIS activity. The inter-disciplinary and trans-national characteristics of the training activities embedded in the NiSIS workshops and symposia activities will have a beneficial impact on the practitioners participating in it, by broadening the spectrum of their competence thus adding innovative techniques based on intelligent technologies.

The consortium consists of many institutions from 12 countries, creating a broad platform for co-ordinated action. The intention is to significantly increase the number of members and to include more private industry Partners in the project.

Co-operation with other FET supported initiatives

As already mentioned in section B.1, we aim at establishing a strong link with other projects on intelligent systems and nature/bio-inspired systems or related areas. This will clearly be the case for the various existing Networks of Excellence in FP5, which are focusing on the spreading of theoretical tools in different disciplines from the fields of biology, economics, operational research, computer science to government, business and industry. Additionally, we expect close co-operation with the activity of FET projects in the different, just-started initiatives of FP6.

NiSIS will build, gather and support new communities of researchers with computer science as the core discipline but with equal contributions from systems engineers, biologists, mathematicians, biochemists and business economists. This will engender an evolution beyond current intelligent technologies and beyond systems biology (i.e. cell dynamics and mechanisms) into “Organic IST”. In this way there will be an integration of concepts into theory/practice for the design and implementation of large, advanced IST systems, while maintaining manageability. These endeavours are expected to lead to STREPS research projects in the short term, and future FET-related proactive initiatives beyond FP6.

5. Potential Impact

The concept of NiSIS is a natural progression/evolution from the Networks of Excellence ERUDIT and EUNITE. ERUDIT's focus was mainly on a single paradigm of *uncertainty reasoning* via Fuzzy logic, which itself has been demonstrated to be suitable for advanced systems design . EUNITE has recognised the need for multiple paradigms in the analysis and design of *adaptive* systems .

NiSIS moves forward into the field of artificial nature-inspired systems driven by phenomena which occur in biological and socio-economic systems and which are relevant to IST. As in EUNITE and ERUDIT, *multi-disciplinarity* is essential, as represented by the multi-disciplinary groups working together within the main research areas mentioned above.

However, a major new emphasis is that of *integration*. In addition to structural and functional aspects of natural system investigation, the theme of simulation involving hybrid knowledge representations of discrete, continuous and linguistic elements requires a methodological step transition in implementation.

Biology is at present a too immature subject to give detailed methodologies beyond existing computerised technology. However, it is beginning to give drivers to stimulate modern computer-based development, while the eventual results will probably come about via serendipity which by definition is unpredictable. Some of the current exciting drivers from nature/biology are:

Adaptivity, Learning, Evolution

An important question is: What organisational principles (at cellular level and beyond) have given rise to the proven huge robustness and scalability in living systems? Many companies in telecommunication (like BT) are interested in this. Maybe we need "cellular" computers, which are "beyond redundancies" such as used in present engineered fault-tolerant systems. The clue is reckoned to be in local/global interacting systems and their integration. It is being demonstrated in drosophila (fruit flies) and yeast (protein complexes and sub complexes).

Optimisation

This is already being applied to information-intensive systems via multi-objective Genetic Algorithms, but is very inefficient. In contrast, Swarm Intelligence is very fast and is beginning to show promise for design optimisation. Genes sequencing, alignment and annotation algorithms are under continuous development for biological research and should be imported into other information-intensive applications requiring optimisation.

Integration of Hybrid Structures

"All cellular mechanisms are integrators of diverse forms of information". This is a non-controversial statement! But, the question is HOW? Many IT providers are interested in this. Biology offers new viewpoints on network connectivities for merging heterogeneous data/information sources.

Hierarchies/Modularity

There is a lot of interest in modularity and evolvability in biology. Computers and cars are designed and built in modular ways, but what about living systems? Thus, structural versus functional modularity and motifs are being demonstrated for linking yeast genes and proteins with signal transduction. Similar work is being done on bacteria. Hierarchies are an in-subject in biology, since they avoid the small-world dilemma of complexity theory. This is being researched by control theorists in the USA producing optimal circuit design via biologically-inspired concepts.

Modelling/Identification

Biology needs to know the right levels of abstraction necessary to elicit the principles which are behind growing structures in nature together with related dynamical functional characterisation. It is now possible to engineer sub-complexes of known structure and to inject them into yeast (and bacterial e coli) which explore the internal biological structures and hence test the current basic assumptions behind modelling hypotheses. This provides identifiability experimentation in a unique manner. This leads to the concept of "Synthetic Biology" (i.e. "Beyond Systems Biology", whose aim is integrated cellular modelling). The big challenge is: What are the fundamental principles undergirding biology? Are they simple, like physics; probably not!

Long term goals and challenges with respect to integration of smart information methods are:

- Constructing efficient, uniformly transparent mechanisms for representing large amounts of knowledge and data, for translating among these representations, and for applying knowledge based inference, learning, and discovery mechanisms to information processing in a variety of forms in extremely large scale knowledge and data repositories.

- Lessening the tension between speed and quality of action by continuing adaptation and extension of knowledge-based reasoning and learning techniques to real-time operation and control of advanced real-world systems that involve hard deadlines.
- Making computers easier to use: more co-operative and customisable, with interfaces that employ natural languages and other modalities to communicate in familiar and convenient ways.

Examples of application-related long term goals requiring smart intelligent systems:

- Combining planning, learning, vision, touch, speech, and other senses in performing everyday tasks, for example house cleaning, cooking, shopping, answering the telephone, making appointments and negotiating or bargaining with other agents for commodities and information.
- Adaptively monitoring, selecting, tailoring and rewriting the contents of electronic information sources (TV, faxes, newswires, the WWW) to inform one of news and events in accord with one's changing personal interests, plans, and purposes.
- Recording, monitoring, and analysing one's medical history and condition over one's entire lifetime, helping to explain and maintain treatment plans, to assess physician advice, and to guide interactions with healthcare providers.
- Operating large scale distributed systems to monitor and maintain the overall system operation, learning how to detect and defend against malicious external or internal attacks (e g. immunotronics).
- Constructing "do what I mean" capabilities for household, educational, and industrial systems, yielding machines that infer desires and intentions of the users and co-operate with them in achieving their aims.

One of the basic technologies for distributed intelligence is the Intelligent Agents paradigm. A similar technology or, better, framework for distributed intelligent behaviour is the Swarm Intelligence paradigm, which derives from the observation of the natural world and extends to man-built artificial systems (e.g. micro/nano machines). In this case, the technology needs are not based exclusively on advanced software development, but addresses the hardware development as well, concentrating on the design of smart embedded electronic devices and micro/nano technologies for implementing some basic intelligence on board. In the area of Swarm Intelligence the basis of a future development is, for example, the Smart Dust (SD), developed by the University of Berkeley, for sensing the environment. Despite the name, the SD does not include any intelligence, but is able to sense and collect or communicate some information to other devices: adding an intelligence layer will involve the study and development of new micro/nano electronic architectures for embedded systems.

In the area of software intelligent technologies, it is forecasted that the development of geographically distributed computing systems, like the ones that are gathered under the umbrella of GRID Computing, will raise the need for intelligent management and control. Similarly, the area of Transportation Systems will need similar approaches for optimising the management and control of such distributed structures.

The advent of wireless smart modules developed for body area mapping and patient monitoring can play a key role in the future of intelligent systems containing networked embedded devices for remote sensing, data collection and management. This will entail structures which are beyond the IST of today i.e. "beyond-bluetooth".

The Break-through?

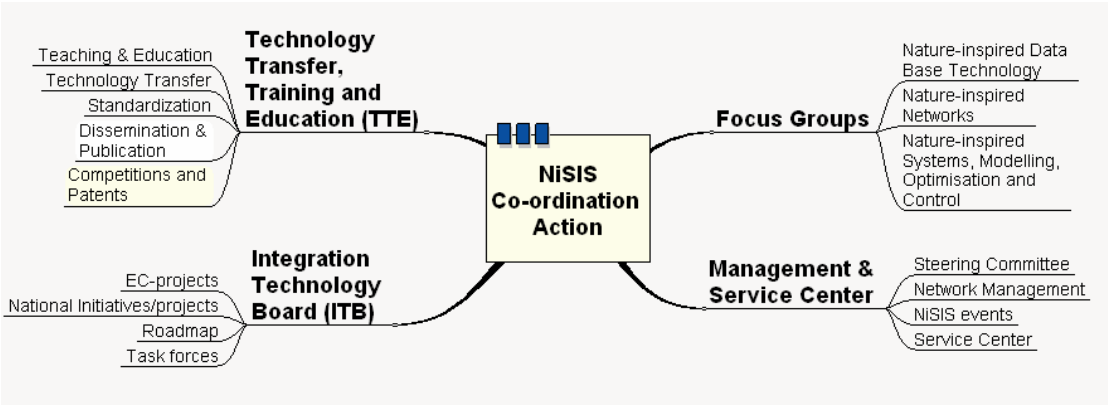
A possible *Break-through* is the concept of the "*Middle Ground".* This reckons that our understanding of science, and hence the implementation of IST systems, is either too simplistic or too complex. This is exemplified by Einstein's familiar saying "scientific models should be as simple as possible, but no simpler". This axiom applies to engineering design, analysis control etc. Thus, flat hierarchies such as the Web lead to huge flexibility but the possibility of uncontrollable chaos. In contrast, most classically-engineered systems in the process and social world are very inflexible but highly manageable. We need to occupy the middle ground of sensible flexibility which facilitates creativity but with robust security against malicious or inadvertent degradation. Another example is that because of the very high dimension of interacting components (more than 30,000 genes and millions of different protein complexes interact in human cells; 4,290 genes in the bacterium *Escherichia coli*), an adequate quantitative modelling of molecular and cellular processes in time and space needs the right level of abstraction.

This implies the concept of *parsimonious systems* in terms of architectures, modular complexity, functional dynamics etc. together with integration of the above ideas. The huge complexity of even the simplest living organisms is driving the assault on the Middle Ground in modelling. Thus, the principle of reduced order modelling is taking root and providing further drive for the break-through required in mathematical understanding to produce parsimonious models (i.e. medium/optimal complexity for the task in hand). To aid this assault, biology is beginning to develop methods of engineering gene injection into yeast cells, such that managed perturbations are introduced into the intact system so that both the methodologies of modelling and their underlying assumptions/identifiability can be tested and, if necessary, adjusted. This is being used to explore gene circuit oscillations, which are beyond conventional electronic devices.

6. Project management and exploitation/dissemination plans

6.1 Project management

The NiSIS Project is organised in four core cells of activities. These are shown in the following diagram.



This structure aims to interconnect multidisciplinary research in an effective scheme: The Focus Groups will deal with theoretical and technological aspects and new developments covering the theme of nature-inspired systems in the areas of :

- Nature-inspired Data Technology
- Nature-inspired Networks
- Nature-inspired Systems Modelling, Optimisation and Control

The TTE (Technology transfer, Training and Education) group will give added-value in terms of cross-disciplinary instruction and motivation etc. for an upcoming generation of young researchers as well as for the dissemination and standardisation. It will also provide the necessary technology transfer, training and education in order to promote the area and enlarge the domain of potential users.

The overall integration of the Project results will be overseen by an ITB (Integrated Technology Board). It will deal also with relationships to other EU-projects and national projects, including the close linkage of the existing Networks and development of the NiSIS Roadmap.

The project management in the Service Centre will support the information flow inside and outside of the Project as well as the project administration and activities including financial management.

Membership

Every European institution with goals and activities which are related to NiSIS can apply to become a Partner. All Partners are represented by contact persons and by participating researchers. An applying Partner should complete a questionnaire related to its competencies in nature-inspired systems research, a description of the institution as well as a summary of the work performed in the area of NiSIS and its choice and motivation to join an NiSIS group. Partner applications are approved by the Steering Committee taking into consideration the advice of the relevant group. Everybody interested in NiSIS activities may register on the mailing list.

The means to acquire new, additional Partners will be:

- Events in the area organised by NiSIS or other institutions
- Publication of press releases and activities of NiSIS
- Direct communication to potential new Partners of high relevance for NiSIS
- Actions of research partners in NiSIS to motivate their (industrial) contacts to enter the project
- Common activities with potential partners from closely-related research areas

Rights and Duties	Mailing List	Partners
Pay membership fees	NO	NO
Sign a membership agreement with ELITE - the prime contractor of NiSIS- in order to join the Project	NO	YES

Be assigned to at least one group	NO	YES
Upgrade to Partner	YES	N/A
Eligible to elect and be elected as a member of a Group Committee or represent the Group in the Steering Committee	NO	YES
Obligation to accomplish the tasks in work package of your group and receive the corresponding financial support	NO	YES
Right to access the NiSIS databank system free of charge and active support by the Service Centre	NO	YES
Receive discount in NiSIS related events or conferences	NO	YES
Apply to form a Task Force	YES	YES
Be 'active' in NiSIS by (at least one activity per year): • Delivering reports • Delivering case studies • Participating in projects which have been initiated within NiSIS or are related to it • Organising NiSIS events • Contributing to the Newsletter • Increasing industrial participation (e.g. bringing new industrial partners to NiSIS)	YES	YES

Management

The Committees (Focus Groups, TTE and ITB) are responsible to co-ordinate the activities which are relevant to them and allocate their appropriate budget under the overall management and auditing of the Steering Committee. Each Committee has to set up rules and decision procedures for its respective Committee (a draft exists already). In addition to these Committees, there are cross-project tasks which will be established and decided by the Steering Committee. The Service Centre will support the execution of these tasks which will include the Roadmap, interdisciplinary Task Forces on special areas of interest for a time limited period, as well as special activities (e.g. round table discussions, workshops, publications) to strengthen the interdisciplinary approach between the different disciplines as well as different application areas involved.

Chairpersons of the different groups are from either Industry/Commerce or from Academia/Research Institutes. An overall balanced representation from the involved disciplines is anticipated.

To assure a successful progression of the Project the work must be monitored and status reports for the CEC must be submitted. All this is carried out by the Steering Committee. The Steering Committee consists of the Co-ordinator, 2 TTE chairpersons, 2 ITB chairpersons, 3 Focus Group chairpersons and one representative of the EC. It will decide strategies and activities of the project. For the first year the chairman of the Steering Committee will be the Co-ordinator. Subsequently, the chairman of the Steering Committee will be elected yearly by the members of the Steering Committee with a simple majority. At the Steering Committee meetings, which will take place at least twice a year, the progress of the project will be reviewed and decisions for future actions will be made. All decisions on the budget for planned and future activities, especially for general activities and cross project tasks, will be made by the Steering Committee.

The core of the Project is the set of 3 Focus Groups which are to deliver the scientific and technological contributions of the programme. They will be responsible for developing a schedule of activities and events, with their own sub-budget, to undertake functions outlined in the objectives summarised in Section 2. All the Groups will channel their activities into achieving the potential impact outlined in Section 5. They will start with an initial core membership of about 6 Partners (spread across the disciplines of computer science, life sciences, engineering, mathematics etc.). They will aim to enlarge their team to about 20 active Partners during the course of the programme.

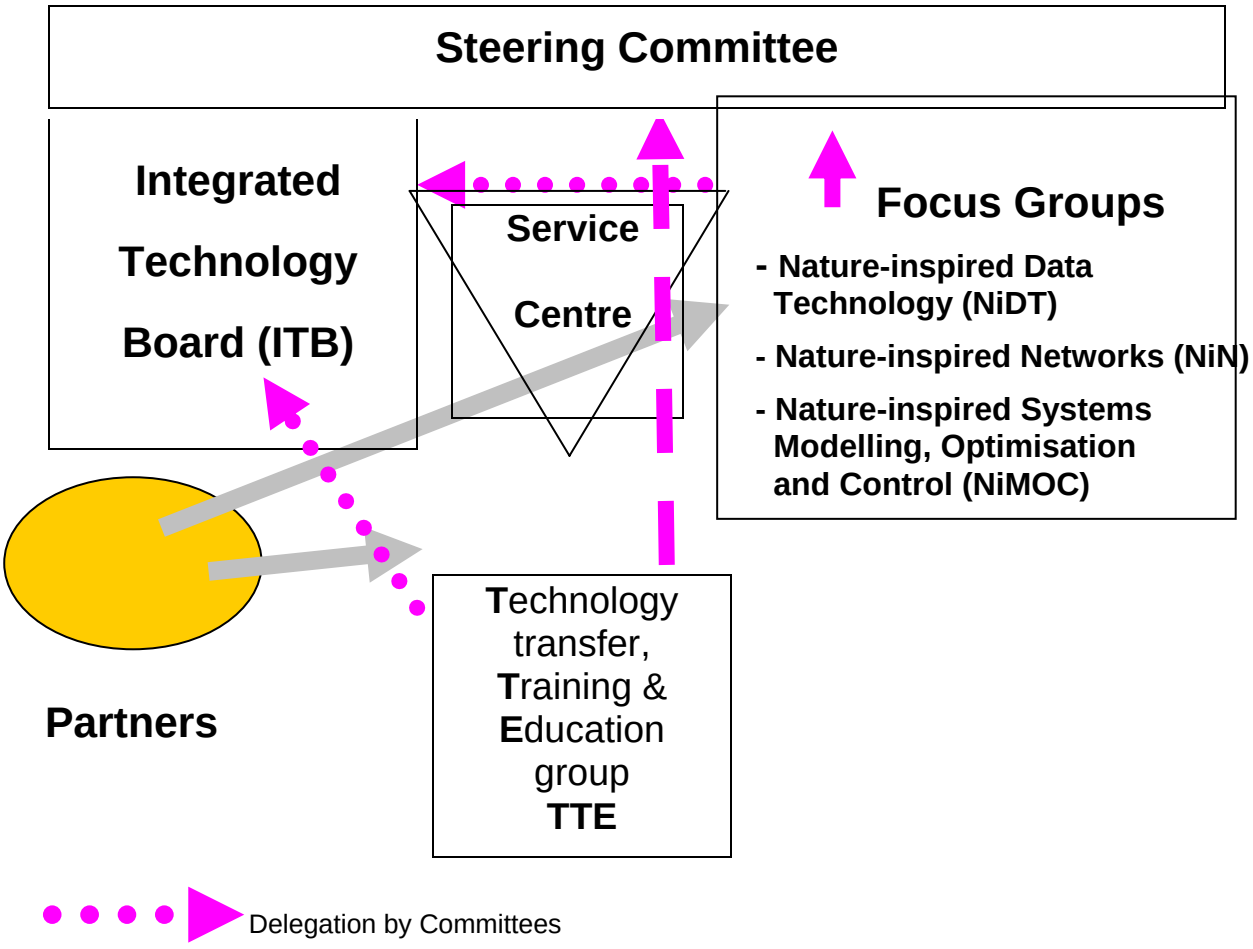
Technology Transfer will take results from the 3 Focus Groups in terms of technological concepts and algorithms, but also contribute challenges via Competitive Workshops concentrating on benchmarking situations taken from real-life relating to IST situations.

Training and Education will give added-value in terms of cross-disciplinary instruction and motivation etc. for an upcoming generation of young researchers.

The overall integration of the Project will be overseen by an ITB (Integrated Technology Board), with participants from all of the above groups and committees, thus providing both "pulling" technology from the life sciences and "driving" the technology into IST via technical co-ordination and a comprehensively designed roadmap. For this committee also an inclusion of outstanding experts and scientists, who are not

members of NiSIS, is planned. A detailed plan with mechanisms for achieving the coordination goals have to be developed in the first three month of the project lifetime.

The co-ordination of NiSIS will be executed by the Steering Committee and achieved via the management component (Service Centre) provided by the ELITE Foundation. This leads to the structure of the project components as shown in the following figure:



The initiation of "Task Forces" is an effective and flexible tool enabling the project to deal with research issues that arise during the lifetime of the project. In NiSIS, the procedure for applying, accepting and managing Task Forces follows a given structure used already in EUNITE, which will be updated in the first 3 month of the project life-time. All NiSIS members will be strongly encouraged to participate actively in initiating Task Forces: practically this will be accomplished by an open call to all project members.

The fostering of scientific development within the theme of nature-inspired systems area will be organised by the Task Forces. They will support NiSIS and also other initiatives and projects with new research ideas and will also advance the forming of interdisciplinary partnerships and consortia. The operation will be mainly in organising workshops and other events concentrating on the development of nature-inspired systems. This, combined with the work done in the Focus Groups, may also pave the way to the development of 'Nature-inspired Systems Science Theory'. Task Forces will also provide materials and ideas for the Roadmap.

Possible Task Force contents could be:

- Gene-regulation network modelling via a modularised architecture aimed at exploring the robustness and adaptivity achieved in biological cellular mechanisms
- Extension of neuronal network modelling of the somatosensory cortical pathways which are responsible for awareness/consciousness both in humans and animals. This may be an analogue of what may be possible in future IT-related machines

- Large, heterogeneous databases containing complex signals such as EEG, EMG and ECG for knowledge mining and on-line decision support
- Utilisation of a comprehensive and enlarging European database on orthodontics where there are many interacting variables and complexity is involved in the risk prediction models to be discovered and implemented for decision support

NiSIS is open to European and Non-European participants including sectors of economy in industry and trade, SMEs, as well as public institutions, scientists, and practitioners in applied research institutions, and universities who are active in the domain covered by the project.

There are different groups in the project:

- Partners are assigned to groups according to the structure described above and have the obligation to accomplish the tasks in the work packages for which the group is responsible. For each work package there is a Partner (a leading Partner), who will lead the effort and organise the activities. These leading Partners are mentioned in each work package header with their participant identification number.
- Mailing List members participate in the events and receive information and services from the Project. Everybody can apply to be a Partner and participate actively in the tasks of the work packages.

All Partners of the Project have to sign a membership agreement with the principal contractor (ELITE). Knowledge management, including IPR issues, education and training, communication, etc. will also be explicitly regulated by a separate annex in the Consortium Agreement. This is of particular importance for NiSIS because NiSIS will “live on” and form the material for other projects. A clear IPR policy will, therefore, be in place at an early stage in the project.

The principal contractor of NiSIS and administrative co-ordinator is ELITE Foundation represented by Karl Lieven. ELITE has a ten-year experience in Project co-ordination (ERUDIT I and II, EUNITE). Therefore, many management tools and procedures are available.

In case of conflict between two or more partners/project members on matters concerning the project, the Steering Committee has to be informed. The Co-ordinator immediately initiates a one-month negotiation phase, and arranges that a Steering Committee member is elected as convening negotiator to help resolve the conflict. If negotiations fail and no solution is found within the one month period, the conflict is solved by a vote among the Steering Committee. In the situation of a tie the vote of the Co-ordinator determines the final decision.

Each Partner who wishes to initiate or to participate in an NiSIS activity has to write an **application** which as a minimum:

- Describes the relevance of the proposed action
- Underlines scope of the action and the target group it addresses
- Gives a clear estimation/justification of budget allocation and possible co-sponsoring.
- Provides a tentative schedule of tasks to be accomplished.
- Provide tangible criteria to measure the success of the activity
- Describes clearly what is the added value for NiSIS and the community
- Defines the activity leader(s) and provides a tentative list of other members that will be involved in the task.

The activity leader has to **report** upon completion of the activity (or provide intermediate reports in case of long duration of the activity when > 1 year) to:

- Show if the scope of the action was achieved (only in final report) as mentioned in the application and provide measurements based on criteria of success
- Provide a full account of budget allocation (based on invoices and original receipts).

All Committee reports are forwarded to the Co-ordinator, the Service Centre and the chairperson of the relevant Committee who summarises the work done by the Committee for the annual report.

Assessment is continuous and per activity of the Project. The general idea behind the monitoring-assessment of activities is as follows:

All NiSIS activities should have a first level of self assessment from the Partners who are already involved and who initiate them. For example, before initiating an activity (Integrating activity, meeting, workshop, etc.) the implicated Partners should clearly set tangible targets (to whom and how many we address the activity, what is the criterion of success etc.) and prepare standard forms for the assessment. Possible risks or opportunities should be defined at an early stage, preferably before initiating the activity.

After the activity, an assessment report stating *what was the target and what was achieved* is forwarded along with the related budget to the Steering Committee where approval is decided. The SC should carefully monitor whether the result coincides with the target set and make comparisons in order to praise or criticise relevant activities. Summary of these assessment procedures will be part of the periodic reports that the project has to submit to the EC.

Assessment material should be created and collected as a natural part of each activity and reporters should strive for easily understandable numerical information. It is expected that with this procedure the effort for further possible external assessment and control from external auditors will be facilitated.

The overall assessment of the Project will be along the following measures:

1. Number of reports and case studies, state-of-the-art surveys and their European-wide distribution.
2. Increase in the number of significant research proposals in the area of NiSIS, specially if they are initiated by NiSIS members.
3. Number of integrated national projects in the area of nature-inspired systems.
4. Number of Visiting Lecturers to Consortium Institutes
5. Increase in the number of scientific, multidiscipline co-authored reports and papers in the area of nature-inspired systems.
6. Initiated events and training activities. The use of training products initiated by partners via the Web. The number of successful cases of scientific mobility exchange.

For all steps described in this section, templates will be prepared and be available at the NiSIS Web pages.

6.2 Plan for using and disseminating knowledge

In this co-ordinated action in the first three month of the project life-time a detailed dissemination plan has to be developed. The annual report on NiSIS, where all activities of the project have to be compiled at the end of each year regarding activities that took place, will be one of the main results for the dissemination task of NiSIS.

The following procedure is planned for collecting and disseminating knowledge of the project partners: Each Partner who wishes to participate in NiSIS activities has to write a report which as a minimum:

- Describes the relevance of his research in the project .
- Underlines scope of his group and the target group it addresses.
- Gives a clear view of research challenges in the project.
- Provides a tentative schedule of tasks planned.
- Provide tangible criteria to measure the success of foreseen activities
- Describes clearly what is the added value for NiSIS and the community

All reports are forwarded to the Co-ordinator, the Service Centre and the chairperson of the relevant Committee who summarises the work planned and disseminated by the Committee for publication.

Collection of material for dissemination is continuous and per committee of the Project.

For all parts in this section, templates will be prepared and be available at the NiSIS Web pages.

The dissemination will be assured by means of courses, summer schools, conferences, and workshops, the contents of which will strongly depend on the needs of technology recipients, and these are envisaged on the following lines

- across different branches in the EU and elsewhere, e.g. applications of solutions developed in one branch to be applied in another one
- across different countries/regions, e.g. applications of solutions developed in one country /region to be applied in another one.

The technology transfer group has to monitor advanced developments in and outside the NiSIS community. One task will be the preparation of this new information in a suitable form to make it available for all recipients including industry, the broader research public and private sector professionals. Due to the Network topic having a high level of multidisciplinary and broad spectrum of research areas the process of information preparation and condensation for reaching the target audience might be more complex than in other networks. For this reason intra-network technology transfer will help to overcome existing barriers in communication encountered when people use different vocabularies, have different motives (research /commercial) and when the content of the transactions may vary from highly abstract concepts to concrete products.

In particular the dissemination will cover

- NiSIS methods (Theory, Tools relevant to e.g.: Parallel and distributed architectures and Algorithms for Artificial Intelligence, Computational Models of Discovery, Machine Learning, Neural networks and Neural Modelling, Genetic Algorithms, Genetic Programming and Artificial Life, Computational Learning Theory, ...)
- applications (i.e. application results from the NiSIS areas of: Biological Evolution, Biomedicine, Social Evolution, Adaptation, Learning, and Innovation, …)

Practical implementation measures of the dissemination will cover :

- Feasibility Challenge Workshops
- Annual Multidisciplinary Symposia employing small integrating projects (task forces) and both conventional and Web-based publications
- Team Competition Workshops providing challenge and vision (similar to those being currently used in EUNITE) and foreseen to take the form of dedicated work of expert groups on Identification of needs, Providing new and better results, and Best Practice Guidelines.
- Summer Schools (especially for young researchers)
- Common databases
- Researcher mobility etc .

Besides face-to-face communication in meetings organised by the Project Committees, different media will be used to strengthen the information flow inside and outside NISIS as follows:

1. *(Electronic) Newsletter*

The Newsletter will be published to disseminate information on new integration activities and research results, technology transfer and other activities of the project. The Newsletter will be available electronically on the Internet.

2. *CD-ROM*

A CD-ROM containing general information on the project, its different activities, and the descriptions of the Partners will be produced annually in connection with the main project event.

3. *Databases*

Different databases will be published and maintained on the Web. These will include the database with detailed descriptions of the Partners (which was already mentioned above) as well as events and a literature database.

4. *Web-site with interactive parts*

A Web-site with information on all project activities and an interactive part will be set up and maintained. This is the basic means for the management of the project and will be established (www.nisis.org). This facility has already been used by the founding consortium partners for establishing the needs and co-ordination of this proposal preparation.

The NiSIS Web page will also integrate the NiSIS activity database (already in use and developed in the NoE EUNITE). The purpose of this database is to co-ordinate the project in a very efficient way and to encourage people by easy-to-use technology to communicate their activities to others in a transparent way. The database should be the tool for easy communication and hence decrease the amount of correspondence to concentrate on the activities itself.

There are password protected functions for reading, changing and editing activities available. Within the editing function one can add new activities of Committees. A major feature of the database is the uploading of files (applications, reports, draft of documents, etc.). This is a very efficient way of repository information being available for the whole Project. Also, via the activity database the financial allocation to each activity as well as the monitoring of all entities of the Project is possible.

6.3 Raising public participation and awareness

Publication and Conferences form the backbone of a coordinated action. It serves two main aspects: the exchange of information and coordination within the activity and the visibility of the project to the outside world. The main form of dissemination of information within NiSIS will be an Electronic Newsletter in direct relation to the Web site as already mentioned above. This will be one of the most relevant means to increase visibility of the project to the different communities.
In a later stage a printed newsletter could be worthwhile. Its purpose is to make the project and its achievement visible to the outside world, especially in industry.

It should be an attractive booklet focusing on a certain issue such as the state-of-the-art and achieved research results by the groups participating in NiSIS. Special issues of existing journals could also serve the same purpose but is more directed to the specialists in a field and not so much to a broader audience.
The project will focus on editing special issues in existing journals devoted to the topics of the committees. Such special issues could consist of the best papers of a NiSIS workshop or symposia or together with a roadmap review article.
The goal is:

- Yr 1.: At least 2 special issues in preparation
- Yr 2.: At least 2 special issues in production
- Yr 3.: At least 2 special issues in production

Many conferences exist already in the field of NiSIS. Nevertheless the organization of an annual NiSIS-symposia on new achievements is planned to increase visibility of the activities in the project.
The primary goal of the key area industrial links is to establish an enduring and close dialog between industry and research and thereby to reduce the obvious discrepancy between the state-of-the-art in research versus actual utilised technology in applications.

7. Detailed Implementation Plan

7.1 Introduction

The NiSIS work plan consists of four work packages, each of which contains a series of tasks linked to specific deliverables. Work package 1 is generically described for the Focus Groups, but will be executed by each Focus Group separately with comparable deliverables and milestones. The appropriate Partners in the respective Committees are responsible for the implementation of the work. In the following paragraphs these responsibilities and the content of the work packages are described. It is planned to have a 3-day Kick-off meeting of the Project in month 2 of the project, where all partners will participate. At day 1 the major topics and organisational schemes will be presented in plenary talks and discussed with clear statements on procedures and measures for the collection, review and assessment of the work planned. Also the cross project activities and integration with other projects (national, European, and international) will be discussed.The core activity at day 2 of the Kick-off meeting will be Committee meetings. At these meetings the detailed programme of work will be reviewed, revised and allocated to the partners. The results (i.e. the activity plan) will be collected in the activity database of the project (see section B7.4). During the third day of the meeting, the activity plans will be presented by the Committee Chairpersons and discussed with all participants to share knowledge and experience.The Kick-off meeting will take place in month 2 of the Project lifetime. The planning, initiating, monitoring, and assessment of the activities will be executed every 6 months.

7.2 Work planning and timetable

The deliverables given in the following table are due at the end of the respective month of the project duration mentioned and are referenced in the work packages and the deliverables. For work package 1 there will be each deliverable per Focus Group.

	Month					
WP	**3**	**6**	**9**	**12**	**15**	**18**
WP 1		**D1-1**	**D1-2**	**D1-3**	**D1-5**	**D1-1, D1-2** **D1-4**
WP 2	**D2-1**		**D2-2**	**D2-3** **D2-4** **D2-5**	**D2-6** **D2-9**	**D2-7** **D2-8**
WP 3	**D3-1**	**D3-2, D3-3**		**D3-4, D3-5**	**D3-1, D3-3**	**D3-2, D3-6** **D3-7**
WP 4	**D4-1, D4-2**	**D4-3**		**D4-4**	**D4-2**	**D4-5**

	Month					
WP	**21**	**24**	**27**	**30**	**33**	**36**
WP 1		D1-3 D1-4	D1-2 D1-5	D1-1 D1-4		D1-3
WP 2	D2-2	D2-3 D2-4 D2-5	D2-1 D2-9	D2-2		D2-3, D2-4 D2-5, D2-6 D2-7, D2-8
WP 3		D3-4, D3-5	D3-3	D3-6, D3-7		D3-4, D3-5
WP 4		D4-4	D4-2	D4-5		D4-2, D4-4

7.3 Graphical presentation of work packages

All work packages will run in parallel over the whole lifetime of the project and therefore no graphical representation is necessary.

7.4 Work package List

Work-package No[1]	**Work package title**	**Lead contractor No[2]**	**Start month[3]**	**End month[4]**	**Deliverable No[5]**
1.1	Nature-inspired Data Technology	17	1	36	D1-1 – D1-5
1.2	Nature-inspired Networks	7	1	36	D1-1 – D1-5
1.3	Nature-inspired Systems Modelling, Optimisation and Control	12	1	36	D1-1 – D1-5
2	TTE	29	1	36	D2-1 – D2-8
3	ITB	2	1	36	D3-1 – D3-7
4	Management	1	1	36	D4-1 – D4-5

7.5 Deliverables list

The work performed by a project is very difficult to assign to specific phases or milestones of the project. Most of the work will be performed continuously over the duration of the project. Nevertheless, for management and progress review of the project, an attempt to represent the expected achievements of some key deliverables is made below. Most of the project tasks do not provide a final deliverable, as in a report, but progress should be seen as ongoing over a three year period. All the work performed per year will be summarised in an annual progress report, where all the activities of the project will be described.

Deliverable/ Milestone no[6]	**Deliverable/milestone title**	**Delivery/ Achieve date[7]**	**Nature [8]**	**Dissemination level[9]**

[1] Work package number: WP 1 – WP n.
[2] Number of the contractor leading the work in this work package.
[3] Relative start date for the work in the specific work packages, month 0 marking the start of the project, and all other start dates being relative to this start date.
[4] Relative end date, month 0 marking the start of the project, and all ends dates being relative to this start date.
[5] Deliverable number: Number for the deliverable(s)/result(s) mentioned in the work package: D1 - Dn.
[6] Deliverable numbers in order of delivery dates: D1 – Dn

D1-1	Input for Roadmap	6, 18, 30	R	RE
D1-2	Proceedings of Focus Group Event	9, 18, 27	R	PU
D1-3	Annual Report; Annual Executive Summary	12, 24, 36	R-M	RE
D1-4	Report on Assessment of Research Activities	18, 24, 30	R	PP
D1-5	Self Assessment Report	15, 27	R	CO
D2-1	Report Feasibility Challenge Workshop(s)	3, 27	R	RE
D2-2	NiSIS Team Competition and related Workshops	9, 21, 30	D	PU
D2-3	Annual Report; Annual Executive Summary	12, 24, 36	R-M	RE
D2-4	Report on Assessment of Team Competition	12, 24, 36	R	PP
D2-5	Patent Guidelines and Service	12, 24, 36	R	PU
D2-6	Best Practise Guidelines	15, 36	R	PU
D2-7	NiSIS Glossary and Dictionary	18, 36	R	PU
D2-8	NiSIS Learning Centre	18, 36	P	PU
D2-9	Self Assessment Report	15, 27	R	CO
D3-1	Call for Task Forces	3, 15	O	PU
D3-2	Establishing Task Forces	6, 18	R-M	RE
D3-3	Survey on on-going Projects and European and national Initiatives	6, 15, 27	R	PU
D3-4	Roadmap Versions	12, 24, 36	R-M	RE
D3-5	Annual Report; Annual Executive Summary	12, 24, 36	R-M	CO
D3-6	Report on Assessment of Task Forces	18, 30	R	CO
D3-7	Self Assessment Report	18, 30	R	CO
D4-1	Project Presentation/Dissemination and Publication Report/Report on raising public Participation and Awareness	6	O	PU
D4-2	CD-ROM with information on NiSIS, Activity Reports and Proceedings of NiSIS Meetings	3, 15, 27, 36	O	PU
D4-3	Release of the Resources and Events database	6	P	PU

[7] Month in which the deliverables will be available or milestone achieved. Month 0 marking the start of the project, and all dates being relative to this start date.
[8] Please indicate the nature of a deliverable using one of the following codes:
R = Report
P = Prototype
D = Demonstrator
O = Other
If milestone, indicate with **M**
[9] Please indicate the dissemination level for deliverables using one of the following codes:
PU = Public
PP = Restricted to other programme participants (including the Commission Services).
RE = Restricted to a group specified by the consortium (including the Commission Services).
CO = Confidential, only for members of the consortium (including the Commission Services).

D4-4	Periodic Progress Report and the Financial Report	12, 24, 36	R-M	CO
D4-5	Project Assessment Report	18, 30	R-M	CO

7.6 Work package descriptions

Work package 1 : 1.1 1.2 1.3	**Focus Groups** Nature-inspired Data Technology Nature-inspired Networks Nature-inspired Systems Modelling, Optimisation and Control						
Work package number	**1**	**Start date or starting event:**			**1**		
Participant id for 1.1	**17**	3	18	20	25	26	27
Participant id for 1.2	**7**	4	7	16	22	23	
Participant id for 1.3	**12**	2	8	9	13	14	15, 24

Objectives

The main objectives of each Focus Group are to:

- Promote cross-disciplinary research into nature-inspired systems within IST focussed areas.
- Disseminate existing and new knowledge in the area over the period of the Project.
- Encourage a growing community, with particular emphasis on younger researchers and co-operation across the EU and beyond.

Description of work

The 3 Focus Groups will be responsible for :

1. Setting the scene
2. Each Committee has to define the Terms of Reference, an initial State-of-the art report and a description and definition of common problems/tasks in the respective area of research.
3. Seeding the project
   - i) Identification of Proactive Research topics and initiation of groups working on these problems.
   - ii) Identification of “white spots”.
   - iii) Reviewing research activities, collection and assessment of results.
4. Planning and running a series of workshops to promote and publicise research in the focus area. Each Group will be responsible for organising scientific events (i.e. symposia, workshops) which promote excellence in its domain. Furthermore, interdisciplinary events involving more than one scientific area have an important role as they will be used for a co-operation and interchange of new ideas.
5. Dissemination of results, surveys and software via standard publication methods and electronic means including the NiSIS Knowledge Management Repository.
6. Contributions to the underlying development of an information science for nature-inspired systems, through definition and sharing of common concepts and challenges and input to the Roadmap.
7. Scientific co-authoring
8. The RTD groups, since they are mostly research-oriented, are the ideal environment where researchers can author joint articles. An effective way of disseminating this joint activity can be by contributing to the scientific e-archives.
9. Initiation of student and researcher exchange
10. Identification of national and international projects and initialising links

11. Annual executive summaries
12. Brainstorm meetings will be organised concerning the important issues that the Committee has identified in scientific problems that are related to the Group. During these brainstorm meetings the participants should identify, describe and diffuse (in public annual reports) the open scientific problems along with actions to be undertaken by the Group. These reports will be used at the same time to monitor the achievements and contribution of the Committee at a scientific level.

Deliverables

- *Annual report on funded projects and workshop activities*
- *Annual executive summary of the committee's achievements*
- *Symposia-Workshops: at least one event per annum*
- *Report on potential researcher exchange and description of national and international projects*
- *Roadmap contribution: annual input for the state-of-the-art surveys and the expected new directions*
- *Publications: An annual publication of the major theoretical contributions*

Milestones

Month 6, 18, 30	Input for Roadmap
Month 7, 15, 26	Organise an event (Conference, Symposium, Workshop)
Month 12, 24, 36	Annual Report; Annual executive summary
Month 18, 24, 30	Report on assessment of research
Month 15, 27	Self assessment report

Work package 2	**TTE**						
Work package number	**2**	**Start date or starting event:**			**1**		
Participant id	**29**	1	5	11	19	21	

Objectives

The objectives of the Technology transfer, Training and Education (TTE) committee are to:

- Support potential developers and users of nature-inspired systems, nature-inspired systems and motivate partners to join the project.
- Facilitate the communication between the committees and partners in NiSIS.
- Raise awareness among end-users with respect to the potential, limits and open questions of existing nature-inspired systems.
- Monitor case studies involving nature-inspired systems.
- Develop strategies to overcome the hurdles based on the high risks of nature-inspired systems, which currently make their application difficult.
- Help partners with respect to patenting and benchmarking technologies for nature-inspired systems.
- Promote success stories of applications of nature-inspired systems and enlarge the potential user base of nature-inspired systems.
- Co-ordination of the educational activities of the project
- Representation of the project externally in education related matters
- Implementation of products and services that serve the Project partners and the general public

Description of work

The work to be performed will cover:

1. *Development of strategy and actions for missing links in the community:* This will cover the actions that will promote the internal (within the Project) and external (between the Project and society) technology transfer. It should deliver a strategy for promoting NiSIS scientific excellence to the end-users and an efficient way to deliver problems from the end-users to the scientific community. An example of such actions is the development of a “Problem Solving Process” framework where the group will try to codify the practical procedure for solving a real problem and then stress the interest of the scientific and end-users community to weak and ill-defined tasks. The focus again will be on identifying those tasks which influence portability and enhance adaptivity. Also, later on the members of the Project can decide efficient ways (for example in a virtual space in the Web) to “sell” competency to the ones that are interested to “buy” services in the field of nature-inspired systems.
2. *Patent guidelines and Patent Service:* The discussion about the unlimited patentability of software patents is very actual. With the background of about several thousands granted European patents on the broader field of " nature-inspired systems related inventions" (from a total of estimated 25.000-30.000 software related patents), most of them held by non European global players from the US or Japan, it seems to be necessary to support SME European companies in this important field. Many of them are high technology oriented using nature-inspired systems developments or related applications, but don’t have enough information and legal advice in the patentability of inventions under National and European law. The Project will establish a set of patent guidelines with open access for all partners. In particular, entrepreneurs should profit by this activity. In a second step the project will offer, with the help of a patent attorney, an individual free of charge first advice for interested companies and developers. In addition, the guidelines will be updated via the use of current examples with related comments.
3. *Benchmarking - NiSIS Team Competition:* The Project will organise competitions to raise awareness among problem holders of the existence of possible solutions and the community of solution providers by providing illustrative solutions to particular problems. Besides its external objectives, the Project will raise awareness of its activity and techniques among members of the Project and permit comparison and benchmarking of different techniques on

particular real-world problems. Typical problems that deal with unstable environments will be sent to the interested project partners seeking solutions with adaptive behaviour with a strong focus of a multidisciplinary formation of the participating team. Besides the Technology Transfer, the competitions are also a useful addition to the educational objectives of TTE.

The work will deliver a practical "Best Practise Guideline" including a set of patent guidelines for inventions in the area of nature-inspired systems on the Web which will contain current patent examples with related comments. Furthermore, individual free-of-charge first advice will be provided for interested companies.

The work in Education to be performed will cover:

1. *The TED server – Knowledge and Education:* A common server for knowledge and education will be established. This is to facilitate information searches and provide overviews of, say, courses offered within the project. The server will contain educational material, as well as more volatile information (news, calendar).
2. *Learning Centre:* Many NiSIS partners are universities and higher educational institutions. This is the basis for building a learning centre offering demonstrators, tutorials, courses, and a library of lecture notes. The learning centre will be an electronic service operating from the server; physical presence of the learner is not necessarily required. A course can be delivered in full or in part and completed afterwards on the Internet. There will be a Web-based examination.
3. *NiSIS Didactic methods:* In order to evaluate Web-based learning methods, a didactic study will be performed. The integration of the Web influences the course contents, didactic method, and examination method. New didactic methods and organisation of the learning are required. Partnerships will be established between project partners to perform experiments and develop Web-based methods for learning and competence development. Experiences will be collected, processed and published in an educational journal.
4. *NiSIS Glossary: Dictionary, Terminology, Definitions:* Language can be a significant barrier for professionals wishing to exploit the potential of others' work. An electronic dictionary will be developed, containing translations of key terms of the profession in the languages of the project partners (or at least English, French, German, Italian, and Danish). This will help to determine a basic terminology in each language. Another barrier for the transfer of knowledge is terminology. The Committee will propose a list of key definitions of the subject area in English. It will be a working document, which project members and students can influence by suggesting additional or alternative definitions.

The above work will result in services and products that can be used by students as well as teachers delivering education on nature-inspired systems, such as on-line lectures and courses, demonstrators, tutorials, textbook material, guidelines, and a journal paper. In addition, in the area of teaching and education an expected outcome is to demonstrate examples of good practice. A further measurable goal is to issue many (about 100) course certificates to students as a result of our course activities.

Deliverables

- *Team competition workshops / Feasibility Challenge Workshop(s)*
- *Report on Team Competition and the related workshops, best practise guideline.*
- *Annual multidisciplinary symposia*
- *Pre-standardisation document defined and a procedure for acceptance started for at least one document*
- *Patent guidelines and service*
- *NiSIS standard requirements for standardisation in Training, Education and Transfer of Technology*
- *Best Practise Guidelines*
- *NiSIS Glossary*
- *NiSIS Learning centre as part of T3/Knowledge management platform*

Milestones	
Month 3, 27	Feasibility Challenge Workshop(s)
Month 9, 21, 30	NiSIS Team Competition and related workshops
Month 12	Pre-standardisation document defined and procedure for acceptance
Month 12, 24, 36	Annual Report; Annual executive summary
Month 12, 24, 36	Report on assessment of Team Competition
Month 12, 24, 36	Patent guidelines and service
Month 15, 36	Best practise Guidelines
Month 18, 36	NiSIS Glossary and dictionary
Month 18, 36	NiSIS Learning centre
Month 15, 27:	Self assessment report

Work package 3	**ITB**						
Work package number	**3**	**Start date or starting event:**			**1**		
Participant id	**2**	1	7	9	12	17	

Objectives

The main objectives of the Integrated Technology Board (ITB) are to:

- Co-ordinate the technical integration of the various groups within NiSIS.
- Co-operate with other groups which are active in the research area of NiSIS.
- Stimulate future developments in the field of NiSIS.

Description of work

This work package consists of the following components:

1. *Co-ordination within the Project*. The ITB committee will act in concert with the SC (Steering Committee) to ensure that there is cross-disciplinary and cross-project technical integration within NiSIS. It will prompt and encourage mutual understanding and activities across the 3 Focus Groups and the TTE committee.
2. *Co-operation with other projects.* Links to NoEs (such as Neuro-IT) will be created. Co-operation will be based on common Task Forces, working groups and inter-project events.
3. *Co-operation with projects and initiatives*. Links will be created in the beginning to EU and nationally financed projects in the nature-inspired systems area. NiSIS will provide possibilities to publish and disseminate results and other information. Common events will be arranged either separately or during NiSIS events.
4. *Roadmap.* The ITB Committee will develop the Roadmap activity via a continuing activity that produces deliverables in terms of separate reports, case collections and also standard scientific publications (both in printed form and on the Internet). Sources of information are Competitive Case Studies, Competitions within the TTE Work plan, Focus Group contributions, Best Practice Guidelines, etc. The Roadmap work will start with the State-of-the-art surveys in the areas covered by the Focus Groups.
5. *Task Forces.* NiSIS Task Forces will be managed by the ITB Committee. The open call for possible Task Forces will be pronounced at the start-up stage. Task Forces may consider topics such as taxonomies, neglected areas, visionary concepts, etc.

Deliverables

- *Report to the SC on co-ordination within NiSIS*
- *Roadmap document (in both paper and electronic versions), providing an annual deliverable with a clear content structure meeting the objectives of NiSIS.*
- *Workshop Proceedings*
- *Report on co-operation with other NoE, projects and initiatives*
- *Task Force Reports*

Milestones

Month 3	Strategy for collecting Roadmap materials from Focus Groups
Month 3, 15	Call for Task Forces
Month 6, 18	Establishing Task Forces
Month 6, 15	Survey on on-going projects and European and national initiatives. Initiating contacts
Month 9, 15, 27	Workshops
Month 12, 24, 36	Roadmap
Month 12, 24, 36	Annual Report; Annual executive summary
Month 18, 30	Report on assessment of Task Forces
Month 18, 30	Self assessment report

Work package 4	**Management (Service Centre)**						
Work package number	**4**	**Start date or starting event:**			**1**		
Participant id	**1**	5	6	11			

Objectives

The main objectives of the management activities are to:

- Set up mechanisms for initiating and approving integrated research
- Integrate NiSIS partners into an effective collaboration, and achieve global recognition of the excellence of the work within the duration of the project.
- Ensure that planned activities and the degree of integration via the activities are defined, initiated, executed and monitored
- Measure success and progress of the integrated activities
- Initiate research directions and ideas and to develop a framework for the Focus Groups
- Ensure cross-communication between Partners
- Resolve conflicts (e.g. same research interests of participating Partners and Committees)

Description of work

The general management of the project is operated by the Service Centre. The activities can be grouped by the following parts :

1. Steering Committee,
2. NiSIS Service Centre, and
3. Project Management.

The Steering Committee is responsible for the following activities :

1. Monitor all integrating activities in the Committees
2. Set the strategies along which activities will be initiated
3. Organise the annual NiSIS meeting and a General Assembly meeting
4. Set the strategy for acquisition of new Partners
5. Assess performance of members and evaluation of membership applications
6. Evaluate the progress of the project and take corrective actions in the event of problems
7. Reporting to the Commission / Approval of report by the commission
8. Approve all officially sponsored NiSIS activities
9. Monitor the budget.

The Co-ordinator and the Steering Committee will be responsible for the overall co-ordination of NiSIS. They will also assess the project activities and assign, when needed, specific tasks not anticipated in the Project's work plan.

1. *Overall co-ordination*
   Co-ordination and design activities are mainly decided in Steering Committee meetings which will take place at least two times each year. Committee Chairpersons are represented in the Steering Committee and it is also possible to invite specialists (e.g. people responsible for different work packages and tasks) to participate. Committees or the Service Centre will carry out the decisions of the Steering Committee.
2. *Annual Symposia*
   The Steering Committee supervises the arrangements for the annual symposium: It takes care of the timing of these Symposia so that other joint events (Committee meetings, publication of results, etc.) are possible at the same event.
3. *Relations with associated and third countries*
   At the commencement of NiSIS, a strategy will be formulated on how participants from the EU associated States will be encouraged to join NiSIS. Also, the Committee should examine collaboration with other (non-EU) third countries. The strategy and the necessary actions are decided by the Steering Committee.
4. *Assessment and evaluation of the progress of the project*
   The Steering Committee should carefully monitor and assess the activities performed by the groups. This assessment will be based on reports that the participants are obliged to

deliver per activity. Furthermore, the Steering Committee should monitor and assess the advancement of the Project as an organisation based on the aims and targets set in B.1 Project objectives and new directions that can emerge during the life of the project. This evaluation will take place yearly and conclude the annual assessment report submitted to the EC.

The main task of the Project management is the administration and day-to-day operation of the project. In detail, it is:

- General administration
- Financial administration
- Organisation/preparation of Steering Committee Meetings
- Organisation of events
- Handling of other Committee activities
- Administrating inquires by the members of the project

The objectives of the Project Management are to:

- provide a central contact point
- ensure a good communication infrastructure which constantly offers access to many kinds of information.

The information infrastructure is responsible for the following tasks:

- General enquires (phone, fax, e-mail,…)
- Promotion of the project
- Information circulation between the members (internal and external information)
- Delivering case studies and state-of-art reports
- Dissemination of research results
- Information on available literature
- Informing about events (researchers, consultants, experts)
- Obtaining and maintaining up-to-date information about members and their activities
- IT structure (Web, software, resource databases, …)

In this Project, the Service Centre will be the central information source. It will be responsible for planning, implementing and maintaining its IT infrastructure. To enable an efficient and project-wide exchange of information, various Web-based and paper-based means will be used. To achieve the objectives of the Project, the Service Centre will be responsible for different tasks that will be ongoing over the whole duration of the project and will be supported on a daily basis.

A Web homepage (www.nisis.de) will be enhanced and maintained. It will contain general and all other available information on the project and its activities. In detail, the Web will have the following content and structure:

General Part

In this section, interested persons will be introduced to the project, get an overview of the different activities, and find the necessary information for joining NiSIS.

Administrative Part

This part will provide useful information for the work package and task leaders and chairpersons of the project. For example, it will contain templates for preparing presentations, information on financial administration, etc. Therefore an infrastructure for the uploading of information and maintaining them in the Web has been established and will be used.

Resources Database (Members, Events, and Literature)

A resources database will be implemented on the Web to provide information on members, useful contacts and their activities. All members of the Project will be asked to complete a questionnaire in this database before they become a member of the project. Additionally, it will contain a database with information on all events relating to the topics of the Project, as well as a literature database.

Interactive Part

The interactive part will be structured according to different work packages and tasks. It will contain all relevant information on the respective area and its activities, i.e. general information, on-line demonstrators, case studies, conference announcements, job offers, etc. For each area an 'electronic group' will be formed to provide a forum for the exchange of all available information and

knowledge between the participants. To make the communication of one group as simple as possible, the participants will be able to send and receive emails, schedule meetings, share files or have 'virtual' meetings. Each electronic group will have the following components: mailing lists, calendar, documents, and a so-called "blackboard" to present and discuss topics virtually on the respective areas.

The implementation of the homepage will be carried out over the first quarter by the Web assistant at the Service Centre. New features, e.g. on-line demonstrators, case studies, conference announcements and job offers will be added continuously.

The NiSIS Service Centre has the following main tasks:

- keep contact with other projects and institutions
- general organisation of co-operation with other projects, projects and institutions
- provide circulation of information to European Universities and industries
- SME-Support Centre, standardisation and patent service
- support of technology transfer, training and education service
- testing, benchmarking and Case studies

These activities will strongly rely on the information infrastructure.

Deliverables

- *Project presentation*
- *Conferences-Symposia-Workshops general co-ordination and assessment*
- *Proceedings of NiSIS meetings*
- *Integrating activities supervision and assessment*
- *Roadmap supervision and assessment*
- *Task Force supervision and assessment*
- *Network self assessment*
- *Web pages*
- *CD-ROMs*
- *Newsletters*

Milestones

Month 1/7/15...	Steering Committee meetings
Month 3	Project description for dissemination and publication
Month 3	Release of the Web homepage
Month 3+	Maintenance and continuous updating of the Web pages and the databases
Month 3, 15, 27	CD-ROM with information on NiSIS, activity reports and proceedings of NiSIS meetings
Month 6	Release of the resources and events database
Month 9	Collection of information for the resources and events database, design and implementation
Month 12, 24, 36	Editing of the periodic progress report and the financial report
Month 15, 27, 39	Network assessment report