EOI for a Network of Excellence on
APPLICATIONS OF NONLINEAR DYNAMICS TO INFORMATION ENGINEERING (ANDANTE)

NEED & RELEVANCE Due to the intrinsically nonlinear nature of real systems, nonlinear and complex phenomena (of which *chaos* is the most spectacular but not unique one) often naturally arise in widely different environments, ranging from chemical reactions, to biological structures, and from electronic circuits, to computer networks. In the past few decades, several research efforts in the field of applied mathematics, chemistry, physics, computer science, and electrical and telecommunication engineering have therefore been devoted to the comprehension of the mechanics of such phenomena, most often in order to avoid them.

Only recently however, the continuous pursuit of both methodological and technological innovation has led the understanding that the proper exploitation of such complex behaviours may produce appreciable advantages with respect to traditional techniques when transmitting, coding, storing, and protecting information [1]. Several research groups spread across the European Community have already obtained important results from this point of view, as briefly summarized in the following.

1. Communications. As a first noteworthy example, a certain class of discrete-time chaotic systems has been shown to be able to generated *optimal* spreading for asynchronous DS-CDMA systems, i.e., that are able to maximize system performance in certain environments [1][2][3]-[5]. Application of similar methodologies to smart antennas systems performance improvement may be also foreseen.

Additionally, the exploitation of slices of chaotic waveforms as carriers to transmit information has shown its potential in multipath propagation conditions [1][2][6]-[8], so that several interesting applications may be foreseen, e.g. in the fields of wireless LANs or indoor radio.

2. Modeling of Multimedia LAN Traffic. One-dimensional chaotic maps have been shown to be able to reproduce the intermittent and bursty processes that are commonly measured in Local Area Network traffic records. The treatment of such fractal-like non-Poisson processes is nowadays a hot topic [9], both from the practical point of view of the design of network apparati and from the theoretical point of view of queuing theory. The construction of simple models for realistic traffic sources has been a substantial contribution of nonlinear dynamics to a field which is felt to have reached the necessary maturity to address design and implementation of new network control units [10][11].

3. EMI Reduction Electro-Magnetic Interference reductions by exploiting nonlinear dynamics is mainly done by altering conventional systems featuring a periodic regime (and thus exhibiting extremely high power spectral density at harmonic frequencies) with the introduction of a suitable jitter. Such techniques have been recently successfully applied both in power converters and in digital circuits and boards, giving rise to efficient solutions which have been employed or even patented by major US manufacturers, such as Intel or Lexmark [12][13]. Recently, further advantages have been obtained by applying complex non-periodic or even chaotic perturbations to timing signals. These perturbation may be due to the operation of switching circuits in a chaos-like regime (see e.g. [14][15]) or to the explicit coupling of the system with a chaos-generator (see e.g. [16]). Both these methods show great potential in alleviating the EMI problem at its origin. For example a reduction of up to 15dB in the peak power spectral density with respect to other patented method can be achieved [16]. With this, shielding and filtering costs are decreased while improving compatibility between nearby apparati.

4. Cryptography and Watermarking The comprehension of the statistical aspects of the processes generated by chaotic maps also led to improvements in fields so closely related to the increasing need for secrecy and security of the digital information era that their importance can be hardly overestimated. For example, the availability of perfectly random bit generators (see e.g. [17]) allows application to key generation for stream cipher systems. Beyond this, digital cryptography based on chaos is also a field of growing interest in which results on code-breaking times are becoming comparable to those of conventional techniques (see e.g. [2][18][19]). Additionally, investigations have come out with applications to the embedding of complex but perceptively negligible signals into multimedia information streams whose authenticity must be assessed, giving rise to watermarking techniques whose efficiency is at least comparable to standard solutions[20].

5. Advanced Design Techniques for RF Circuits and Oscillators Besides the previously considered applications where the statistical features of the processes generated by complex systems plays a paramount role, the practical importance of the more classical studies of nonlinear dynamical systems behaviour in terms of bifurcation phenomena should not be underestimated. As an important example, such techniques can be employed for studying the global dynamics and the bifurcation processes in RF oscillators and circuits employed in wireless terminals, with the aim of developing new and efficient design rules and simulation algorithms, mainly based on suitable extensions of harmonic balance techniques [21][22].

6. Biologically Motivated Coding Scheme of Perceptual Information A last important application of nonlinear dynamics where EC research groups have achieved significant results is to devise an alternative scheme of associative memory exploiting the chaotic principles of neural activity [23]. Indeed, the EC is already financing the investigation of a biologically motivated coding scheme of perceptual information, which identifies interesting states with almost periodic behaviour instead of fixed equilibria. If no perceptual stimuli are fed into the system its state explores a wide chaotic attractor, whose size is also further when the input signal has nothing to do with its internal dynamics. On the contrary, if the input signal is related to the internal structure of the attractor, the system "locks" onto it, i.e. it tends to synchronise with the input thus reducing the size of its chaotic attractor. At the same time, exploiting the fact that a single chaotic dynamical system produces a whole family of trajectories that are different but nonetheless very similar, a modelling technique has been developed to model an entire class of approximately periodic signals by means of a single chaotic system. The synchronisation phenomenon and the modelling technique have been combined into a chaos-based pattern recognition/classification method for approximately periodic signals [24][25]

Relationship with priority thematic areas

Most of the considered tasks where nonlinear dynamics based techniques have been successfully applied fit well in a number of different priority thematic areas. In fact, the possibility of devising *new methodologies for cryptographic keys generation* as well as the development of innovative techniques for *watermarking of multimedia contents based on chaos* addresses the **priority area 1.1.2.i (**Applied IST research addressing major societal and economic challenges: technologies for trust and security). The possibility to enhance spectral efficiency in *DS-CDMA systems employing chaos based spreading sequences* as well as the proposed innovative *network analysis and design based on nonlinear/non-Poisson models for traffic* are directly related to **priority area 1.1.2.ii** (Communication, computing and software technologies: Communication and network technologies, mobile and wireless systems and networks beyond 3G, spectral efficient protocols). It is likely that this activity will trigger the application of similar methologies in related field such as smart antennas systems performance optimisation. On the other hand, once fully developed the *new design methodologies for RF-oscillators relying on bifurcation analysis techniques* will surely benefit **priority area 1.1.2.iii** (Components and Microsystems). The development of new methodologies for *modelling and retrieving knowledge with bio-inspired associative memories based on oscillation and chaos* partially addresses **priority area 1.1.2.iv** (Knowledge and interface technologies: acquiring and modelling, navigating and retrieving, representing and visualising, interpreting and sharing knowledge). Finally, the design of enhanced EMC circuits and systems based on nonlinear signal processing techniques, thought of an extremely wide scope, is also directly linked to **priority area 1.1.4.i** (Aeronautics: Improving aircraft safety)

Needs of ANDANTE Although such leading competence exists trough Europe exists, a rapid scan on the main site for patens application (see f.i. http://ep.espacenet.com/) reveals most of the intellectual property and industrial products profitably exploiting nonlinear dynamics are owned by Japanese and US researchers and enterprises. Additionally, several methodologies based on nonlinear dynamics has been turned into commercial product, as for

instance, the chaos-based radar navigation control systems and the chaos-based routing proposed by Mitsubishi electrics (for additional details see http://www.mitsubishielectric.com/news/sc/ts_b_3.html and http://www.merl.com/projects/chaoslan/).
This may be ascribed to the absence of coordination between leading European research groups and of a proper technology transfer between academic and industrial world. One of the aim of the present Network of Excellence (NoE) is to fill this gap by trying to unite these separated communities and to provide to them proper coordination points. Additionally, the role of the involved industries will not be considered as a simple collector for technology transfer, but as an active stimulus to ensure that academic experts in nonlinear dynamics focus on problems with realistically short time-to-marked product applicability.
The disciplines involved in ANDANTE and mastered by its perspective participants are numerous and range from applied mathematics, physics, computer science, to electrical and telecommunication engineering. It is therefore likely that the close cooperation of the involved researchers and industries will result in the gain of several intellectual property rights in various fields. This will guarantee royalty income for active network members. Without an immediate start of a NoE the great potential of the present European R&D scenario is likely to be lost, thus increasing the gap between EC and the US and Japan.

EXCELLENCE: The perspective members of the consortium are composed by leading experts in their respective field, as it is reported in details in the following table. Even if this is the first temptative to form a so large consortium in this field of application of nonlinear dynamics, several "clusters" of the members already posses an appreciable experience of fruitful collaborations such as

Joint technical projects

1. UCC, EPFL, UMM, TUD, UOB-ARCES, UOF, BME, CNM cooperated in the framework of the ESPRIT project 31103 INSPECT (Innovative Signal Processing using Chaotic Dynamics)
2. UOBI, UOB-ARCES, UOF, TUD, UCC are currently cooperating in the framework of the EPSRC Research Grant on "Chaos, Communication and Randomness"
3. UOBI, UOB-ARCES, UOF are currently cooperating in the framework of the *Royal Society* European Science Exchange Programme
4. EPFL, UOCM are currently cooperating in the framework of the EC project APEREST (Approximately Periodic Representation of Stimuli)
5.

Organization of events, e.g.

1. IEEE International Specialist Workshop on Nonlinear Dynamics of Electronic Systems (NDES, annually since 1994, TUD is one of the founding members)
2. IEEE-IEICE International Symposium on Nonlinear Theory and its Application (NOLTA98 and NOLTA2000)
3. IEEE International Symposium on Circuits and Systems (ISCAS2000)

Dissemination of results, e.g., special sessions at the major international conferences of the Circuits and Systems Community, and several special issues of major international journals as, the special issue on "Noncoherent Chaotic Communication" of the IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS – PART I (UCC and BME acted as quest editors, and contributors include TUD and EPFL), December 2000, as well as the May 2002 special issue on "Applications of Nonlinear Dynamics to Electronics and Information Engineering" of the PROCEEDINGS OF THE IEEE (EPFL, UMM, UOB-ARCES, UOF acted a guest editors, and the contributors include also TUD, UCC, CNM, BME). Additionally UCC, UOB-ARCES, UOF acted as guest editors of the first comprehensive volume on application of chaotic dynamics to telecommunications ("Chaotic Electronics in Telecommunications", CRCPress, 2000), which includes contributions of TUD, UMM, CNM, BME

Consortium Members, Acronym, (**COUNTRY**) (all agreed)	Demonstrated Competence ➢ Potential Role in the NoE

Swiss Federal Institute of Technology EPFL (**CH**), Laboratory of Nonlinear Systems, (*Prof. Martin Hasler*), Martin.Hasler@epfl.ch
One of the first investigator to draw attention of the engineering community onto the potential of chaos in electrical circuits and one of the first to tackle exploitation of synchronization and related phenomena for transmitting information. Leading expert in Europe for the exploitation of chaos in communication and signal processing. EPFL has been practically the first to employ deterministic chaotic dynamics for implicitly modelling the randomness of signals and to subsequently exploit such modelling technique in a chaos-synchronization-based temporal pattern recognition method. ➢It is expected that the know-how of EPFL in chaos-based representation of diversity, nonlinear signal modelling, and in the mathematical principles of synchronisation of small and large ensembles of chaotic systems will be of fundamental importance in the development of models for representing, interpreting, and sharing information based on the chaotic principles of neural activity. Furthermore, in the domain of application of chaos for communications, EPFL will contribute its expertise in the analysis and design of channel coding and modulation schemes based on chaotic systems in order to advance the state of the art in digital data transmission exploiting nonlinear dynamics.

University of Birmingham, UOBI (**UK**), School of Mathematics and Statistics, (*Prof. A.J. Lawrance*), A.J.Lawrance@bham.ac.uk
Leading expert in chaos based communication modelling from the point of view of exact mathematical and statistical theory in order to discover where optimality may be gained over present developments. ➢ Professional experience as a mathematician and statistician with previous fruitful cooperation with engineers. Gain of fundamental understanding of the engineering theory and objectives involved and use of a high level of mathematical and statistical expertise to give added engineering value to the success of the projects

University of Camerino, UCA (**I**), Dep. of Mathematics and Computer Science, (*Prof. Stefano Isola*), stefano.isola@unicam.it
Expert in the field of weakly ergodic theory, complexity theory and Spectral Theory of weakly chaotic dynamical systems. ➢ Support for the theoretical investigation of chaotic process related to engineering problems (LAN multimedia traffic modelling, optimisation of communication system performance). Close cooperation is expected with EPFL, UMM, UOB-DEIS, UOF, QM-UOL, TUD in the analysis of statistical properties of chaotic process in different signal processing tasks

Tech. University of Clausthal, TUC (**D**), Institute of Theoretical Physics, (*Prof. Thomas Prellberg*), thomas.prellberg@tu-clausthal.de
One of the pioneers of the research on intermittency phenomena in one dimensional chaotic maps and spectral analysis of operators. ➢ Theoretical support for mathematically demanding research areas in dynamical systems. The involved mathematical are diverse, ranging from asymptotic analysis of q-series to spectral analysis of operators and potentially linked to those of interest in Information Engineering applications. Cooperation in the network is similar to UCA.

LEAcom SA, LEA (**F**), (*Dr. Hervé Dedieu*), hdedieu@leacom.fr

Founded in 2000 but already European leader for xDSL passive and active splitters. In less than two years, the company has become an acknowledged partner of most European TELCOs and has signed several OEM agreements with the major DSL vendors. Recently, LEAcom is developing, marketing and selling a new technology allowing the coupling of fast DSL signals across the SOHO powerline network. With LEA's gateway products (so called ELEKTRA), the customer is now able to build an Ethernet network without any rewiring. The LEA's technology is based upon a patented CDMA approach. The performance are compliant with the very conservative regulatory requirements which are currently emerging from the ETSI standards (distribution of allowed power radiated across the RF band)

➢LEAcom is interested in the development of spread spectrum sequences suited to power line channels, i.e. in the design of "optimal" spread spectrum sequences taking into account the noises which are specific to the power line channels as well as the non-stationarities due to change of network impedance and configuration. Topics 1. (Chaos-based communication), 2. (LAN multimedia traffic modelling) and 3. (EMI reduction) of those mastered by the ANDANTE consortium may lead to appreciable performance improvement of our current products or of those under development

University of Bologna, ARCES: Excellence Research Center on Electronic Systems for Information and Communication Engineering, UOB-ARCES (**I**), (*Prof. Riccardo Rovatti*), rrovatti@deis.unibo.it

UOB-ARCES had important achievements in the field of piecewise-linear (fuzzy) approximation of non-linear systems and contribution to give a first significant impulse to the application of statistical theory of dynamical systems to information processing problems. Additionally UOB-ARCES appreciably contributed to the exploitation of chaos in DS-CDMA systems by proving that chaos-based spreading is *optimal* in certain scenarios. Additionally, it cooperated with UOF in the implementation of a working prototype of chaos-based DS-CDMA system, which is the first chaos-based communication system outperforming the corresponding conventional one. UOB-ARCES gave also significant contribution to the modelling of LAN multimedia traffic with chaotic maps and to the development of new modulation methodologies for generating high-EMC timing signals, both in cooperation with UOF. UOB-ARCES recent interest are focusing also on security issues related to the generation of cryptographic keys with chaotic system.

➢ With this large spectrum of competences, UOB-ARCES is likely to contribute to several activities inside ANDANTE ranging from chaos communications systems (with EPFL, UOBI, UOF, BME, UCC, CNM, LEA, TUD), to the exploitation of chaos-based signal processing to EMI reduction (with TUD, UOS, UOF) and to multimedia LAN traffic modelling (with TI-C3S, QM-UOL, LEA, UOF, and TUC, UOC for what concerns the more theoretically oriented aspects of the analysis).

University of Mining and Metallurgy, Krakov, UMM, (**PL**), Dep. of Electrical Engineering, (*Prof. Maciej Ogorzalek*), maciej@zet.agh.edu.pl

Leading research group in the field of analysis of nonlinear and chaotic circuits, implementations of chaos control methods, chaos-based signal processing including coding and compression algorithms and noise removal. Additionally, UMM possess competence on synchronization phenomena, pattern formation in arrays of coupled nonlinear electronic circuits.

➢ Interaction to the NoE filed of interest are foreseen especially with UCA, TUC, UOF and UOB-ARCES to determine the characteristics of the family of chaotic maps assuring the best compression ratio as a function of the characteristics of the input information. As far as the synchronization issue are concerned, close cooperation can be expected with EPFL and UOCM in the use of arrays of chaotic circuits for the realization of a chaos-based associative memory.

Telecom Italia S.p.A, TI-C3S (**I**), Learning Services, Competence Center on Complexity Studies, (*Dr. Fabrizio Davide*)
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Telecom Italia S.p.A. is the holding company for the Telecom Italia Group, Italy's largest telecommunications operator with activities ranging from fixed wire networks to mobile and satellite communications, multimedia services, IT, broadcasting, manufacturing and plant installations. With 22,300 thousands fixed network subscribers, 22,6 million wireless customers in Italy, 27,8 million wireless customers in the international markets and 4,6 million registered Internet access users (June 2001) Telecom Italia is one of the world's most important telecommunications operators, both in terms of group revenues (15,589 million euro on the first half of 2001). From a strategic point of view, Telecom Italia aims to maintain its leadership while reinforcing its competence and innovation initiatives. Telecom Italia Learning Services (LSE) offers training in presence and at distance, through a best-of-breed e-learning platform, develops joint actions with universities and national and international organisms in order to fill the knowledge gap inside and outside the Group, and give guidance to the other areas.

➢ Since nonlinear dynamics and chaos have shown potential interaction with different fields of ICT, Telecom Italia has recently created a research group focused on the study of complex systems (Competence Center on Complexity Studies – C3S), with the aim of acquiring the necessary know-how to turn the high potentials of nonlinear dynamics based techniques into industrial products. C3S, at the moment, address his research efforts on modelling of nonlinear dynamics and complexity systems for communication, computing and software technologies and on the exploitation of chaotic techniques in different domain of signal processing. For the problem of LAN traffic modelling TI-C3S will also act as source of experimental traffic traces. Finally, C3S can offer to ANDANTE his strong experience in ICT, and develop an e-learning platform for data transfer and information sharing among the network group.

University of Ferrara, UOF (**I**), Department of Engineering, (*Prof. Gianluca Mazzini, Prof. Gianluca Setti*)
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UOF has internationally recognized experience in modelling statistical aspects of telecommunication systems from DS-CDMA to LAN traffic and in the field of highly connected non-linear dynamical systems. It gave also a first significant impulse to the application of the statistical dynamic approach to electrical circuits and systems. UOF closely contributed with UOB-ARCES to theoretical analysis of chaos-based DS-CDMA systems and did a substantial work in the implementation of the fist chaos-based DS-CDMA system prototype. More recently UOF focuses on EMI reduction exploiting chaotic dynamics, both from the theoretical and experimental perspective and on multimedia LAN traffic modelling. Finally, interesting preliminary results on the analysis of chaos-based cryptosystem and chaos-based cryptographic keys generation have been also obtained.

➢ The range of interests as well as the developed competence are very similar to UOB-ARCES, since the two research groups worked in close collaboration since 1997. UOF may additionally add to the consortium its competence with regard to implementation issues, being a natural candidate for developing a first prototype of a chaos-based artificial traffic sources. UOF is also the proposer of the EOI and candidate for the network coordination.

Technical University of Dresden, TUD (**D**), Dep. of Electrical Engineering, (*Prof. Wolfgang Schwarz*), schwarz@iee1.et.tu-dreden.de

TUD possesses a deep and long experience on the statistical analysis and design of chaotic systems for communication and for encryption. Additionally, it has been one of the first groups to propose the use of chaotic switching power converters for EMI reduction and has already acquired appreciable results in their analysis. Finally, TUD has also a good experience in the design and implementation of nonlinear electronic circuits both conventional (mixers and oscillators) and non conventional (chaotic) ones.

➢ For EMI reduction, the competence in the analysis of chaotic switching power converter perfectly complement the expertise of UOS as well as the methodologies proposed by UOF and UOB-ARCES . The competence in design and implementation of nonlinear circuits will be surely exploited in the cooperation with PT, UCC, BME and possibly LEA. Additionally, TUD will cooperate with UOB-ARCES and UOF in the exploitation of chaos for security issue and with EPFL, UOF, UOB-ARCES, UOBI in the filed of chaos-based communication systems.

Institute of Microelectronics of Seville, Spanish Microlectronics Center, CNM (**ES**), (*Prof. Angel Rodriguez-Vasquez*), angel@imse.cnm.es

Founded in 1985 and employing 67 permanent staff members, CNM is world leader in the implementation of analog and mixed-mode non-conventional nonlinear circuits (ranging from fuzzy circuits and system to chaotic signals generators, to large lattice of nonlinear dynamical systems for image signal

processing) and has a wide and recognized experience also in the design and implementation of more conventional electronic systems (sigma delta data converters, PLL, switched capacitors filters, to arrive to whole systems on a chip).

➢ The deep expertise of CNM in nonlinear dynamical circuits will surely trigger many cooperation in the ANDANTE framework, f.i. in the development of new design methodologies for RF oscillators and circuits (with PT, UCC, BME, TUD), in the implementation of chaotic circuits and systems (with UOB-ARCES, UOF, EPFL, TUD, UCC, BME), as well as possibly new DSL circuits for LEA (in cooperation with UCC, UOF, UOB-ARCES)

Polytechnic of Turin, PT (**I**), Dep. of Electronics, (*Prof. Marco Gilli*), gilli@polito.it

PT possesses a long and deep experience in the field of analysis of bifurcation phenomena in nonlinear RF circuits and oscillators and in the development of efficient numerical algorithm for their prediction, which could be easily added as plug-ins for a numerical circuit simulator.

➢Capability of devise new and accurate design procedures for nonlinear RF circuits and oscillators based on nonlinear dynamics analysis techniques. Interaction on the analysis of dynamics behaviour of electronic circuits are expected at least with UCC, BME, CNM and TUD

University Complutense of Madrid, UOCM (**ES**), Dep of Applied Mathematics, (*Dr. Fivos Panetsos*), fivos.panetsos@bio.ucm.es

UOCM has a strong experience in mathematically studying the conditions that have to be accomplished by neural cells for implementing signal processing and signal coding based on the resonant behavior of oscillating neurons. Furthermore, it has as well a strong experience in computational studies of the signal processing and coding capabilities of neural membranes based on the interaction of voltage-depending channels.

➢ It is expected that the modelling experience of UOCM will be of paramount importance in the development of biologically inspired models for representing, interpreting, and sharing information. Close cooperation is expected especially with EPFL and UMM

Queen Mary, University of London, QM-UOL (**UK**), School of Mathematical Sciences, (*Prof. David K. Arrowsmith*), D.K.Arrowsmith@qmul.ac.uk

The Packet Traffic Group (Mathematics-Electronics) has made sustained investigations of nonlinear models for producing long-range dependent traffic in networks. The ongoing work involves a theoretical study of auto-correlation properties of aggregate traffic, and, also, simulations of LRD networks. There is also an internationally recognized Dynamical Systems group at QM with a particular expertise in the spatiotemporal modelling and the statistical physics of dynamical systems.

➢ Dealing meanly with modelling of multimedia LAN traffic, the main role of UOL-QM is in cooperation with TI-C3S, UOF, UOB-ARCES, LEA and, from a pure theoretical point of view UOC and TUC to devise the best models for traffic sources depending of the network conditions.

University of Sannio, Benevento, UOS (**I**), Department of Engineering, (*Dr. Mario di Bernardo*), dibernardo@unisannio.it

Reknown expert on the analysis and control of piecewise smooth dynamical systems and their bifurcations; applications to power electronic systems and vibroimpacting machines. Research interests include the modelling of communication networks, the analysis of so-called small-world phenomena and the rigorous analysis of performance of chaos-based communications schemes.

➢ Development of new design methodologies for switching power converters with reduced EMI exploiting chaos, in cooperation with TUD, UOF and UOB-ARCES. Analysis of small word phenomena will be applied to the analysis of the internet network with the aim of developing and efficient traffic simulator on cooperation with TI-C3S, UOB-ARCES and UOF

University College Cork, UCC (**IR**), Department of Microelectronic Engineering, (*Prof. Michael Peter Kennedy*), Peter.Kennedy@ucc.ie

UCC has expertise in the application of nonlinear dynamical techniques to the study of oscillators, data converters, and phase-locked loops. The Department of Microelectronic Engineering also has experience in mixed-signal test, low-power digital design and RF circuits, and plays a leading role in the development of mixed-signal design in Ireland.

➢ With its strong links to leading international companies in the mixed-signal design industry, UCC will focus nonlinear dynamics research on problems of practical relevance in the areas of circuit design, mixed-signal test, and CAE. Close cooperation in the NoE is expected at least with UOB-ARCES, UOF for the applications of low EMI timing signals in integrated circuits, with PT and TUD for development of new design methodologies for RF oscillators, as well as LEA for the design of new DSL transmitter-receivers for power-line network channels.

Budapest University of Technology and Economics, BME (**HU**), Dept. of Measurement and Information Systems, (*Prof. Geza Kolumban*), kolumban@mit.bme.hu

BME chaotic systems team is the inventor of the DCSK and FM-DCSK modulation scheme. It significantly contributed to the theory of chaotic communication by obtaining closed-form performance bound of performance in AWGN channels and by extending the idea of conventional communications systems to chaotic communications. BME also cooperated with UCC, and CNM for the implementation of the first working prototype of signal-level chaos communication systems based on FM-DCSK. BME team leader has also a previous experience in developing microwave local oscillator for high capacity microwave radio relay systems and frequency synthesizers for satellite and spread spectrum
digital communication systems.

➢ In the NoE framework, BME expect to closely cooperate with UCC, PT and TUD for studying new design methodologies for RF oscillators and with UCC, UOS, UOBI, EPFL, UOB-ARCES,UOF, CNM for the design of chaos-based communication systems.

Some Related past projects of the perspective participants

Member	Selected Related Project (bold are founded by EC)
EPFL	**INSPECT** (Innovative signal processing exploiting nonlinear dynamics), **HIMARNNET** (Speech recognition using a combination of hidden Markov models and neural networks), **SACPA** (Study of AC losses in tape relevant to industrial high power applications), **BIGPOWA** (High current Bi-2233 conductors with innovative wire geometry for power applications), **APEREST** (Approximately Periodic Representation of Stimuli)
UOBI	*Ford Motor Company* 1995 Engine Mapping Research, *EPSRC* Research Grant (Chaos, Communication and Randomness), *DERA* Malvern Contract *(Chaos Communications Research Support), Royal Society* European Science Exchange Programme (with UOB-ARCES and UOF)
UOC	**European Research Training Network** (Mathematical Aspects of Quantum Chaos)
TUC	**PROCOPE** (Combinatorics of Random Structures, Analysis of Algorithms, and Dynamical Systems), *DFG* (Investigation of the Domb-Joyce model)
LEA	MEDEA+ pan-European consortium through the so-called HYPERLAN project
UOB-ARCES	**INSPECT**, **ESDEM** (23643), *EPSRC* Research Grant (Chaos, Communication and Randomness)*, Royal Society* European Science Exchange Programme (with UOBI and UOF)
UMM	**INSPECT (**first phase), **COSYC of SENS** - Research Training Network (Control, Synchronization and Characterization of Spatially Extended Nonlinear Systems)
TI-C3S	FET: **NEUROBIT** (IST- 2001-33564), **I-LEARNING** (IST-2001-38861), Filed of e-Work, mobile applications, e-learning and human

	interfaces: **ANGELO** (IST- 1999-11696) **MOBILearn** (IST 2001-37187), **E-Locus** (IST-2001-38790)
UOF	**INSPECT (**subcontractor), **DEPAUDE** (IST-2000-25434) *EPSRC* Research Grant (Chaos, Communication and Randomness)*, Royal Society* European Science Exchange Programme (with UOBI and UB-ARCES)
TUD	**INSPECT (**first phase), *DFG*: (Design of Nonlinear Circuits and Systems), *BMBF* (Operating behaviour and Applications of aperiodically operated DC-DC-Converters), *BMBF* (Model support for Planning, Implementing, Test and Diagnosis of Data-Networked Buildings)
CNM	**SPRING** (Scientific Multidisciplinary Network for metering), **DICTAM II** (Dynamic Image Computing Using Tera-Speed Analogic Visual Microprocessors), **RAPID** (Retargetability for Reusability of Applications-Driven-Quadrature D/A Interface Block Design), **MIXMODEST** (Mixed Mode in Deep Submicron Techonologies), **INSPECT**, **AMADEUS** (Analog Modelling and Design Using a Symbolic Environment)
PT	*MURST* (Design and implementation of a real-time system, based on neural algorithms, for information extraction based on stereoscopic vision)
UOCM	FET: **ROSANA** and **APEREST,** RTD: **C145/91** (Application of the neural group selection theory in pattern recognition), *CICYT* (Chemical reactor control using neural networks), *BRITE/EurAm II* (Powerful systems for identification and control of highly non linear processes using neural networks), *NATO* (Role of corticothalamic projections on tactile information processing)
QM-UOL	*EPSRC* (Chaotic control for fast resource management), *EPSRC* - Relative strengths of different sources of LRD in Networks
UOS	**SICONOS** (simulation and control of nonsmooth systems), *DERA* (Application of control theory and nonlinear dynamics to chaos based communications scheme), *EPSRC* (Analysis of sliding bifurcations), *EPSRC* (Analysis and Control of bifurcations in nonlinear flight mechanics), *Jaguar Research Labs, Coventry UK and EPSRC* (Analysis of self oscillations on automotive drivelines due to the presence of backlash)
UCC	**INSPECT**
BME	**INSPECT**, Project founded by Hungarian research foundations "analysis of novel transceiver structures implemented by the System-on-a-chip (SoC) concept" and "analysis of mixed signal circuits which can be described by the event-driven models"

INTEGRATION AND STRUCTURING EFFECT: The understanding and the application of nonlinear dynamics within the context of modern engineering entails the interaction of many disciplines such as applied mathematics, physics, computer science as well as electrical, electronic and telecommunication engineering. Hence, any large scale development in the fields depends on a real interdisciplinary effort that, by now, cannot be undertaken by any of the many research bodies involved that are scattered both geographically and in competence.

This is where the benefits of a network of cooperation come into play. Membership in an organized and coordinated effort will surely help the partners to put results obtained by exploiting the local expertise within a more general framework in which development opportunities as well as most promising lines of investigation become more clear. From this point of view, the involvement of industrial bodies of various scales will surely strengthen the possibility of making academic effort focus on topics and applications of greater industrial and societal relevance.

To promote the growth of such a common view of the engineering perspective of nonlinear dynamics the network will plan periodical meetings involving member's representatives with the aim of identifying key issues that need to be addressed, solicit partners to take a role in their solutions depending on the specific expertise, and supporting possible take-ups of the developed technologies.

A basic tool for this rapid information exchange and continuous merging of experiences into a more global picture of the field will be the availability of a web-based virtual meeting point providing for results announcements, focused news, query and answer posts, on-line workshops and meetings, electronics newsletter delivery, announcements of position openings, etc.

Beyond this virtual information mobility, one of the tasks of the newborn network will be to foster actual researchers mobility at the PhD and post PhD level between partners as well as the organization of dedicated schools highlighting the main advancement in the field along with their most successful or promising applicative outcomes.

It is easily foreseeable that participation in the network activities will greatly improve the way in which members

- use or share their resources, thus optimizing the quantity and quality of the research product
- plan their research effort, thus increasing both specialization, complementarity and, in the mean times, long term view
- communicate their results to potential application-oriented bodies and society, thus creating a uniform entry point for information sharing within the network as well as towards external agents

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