

# *Autonomic Network Computing - Science*

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**Brief explanation** – Towards a theory of Autonomic Network  
Computing

# Autonomic Network Computing (ANC)

- **Ambition**

- Live organisms have the remarkable property of *self-healing*. Two fundamental features are on the basis of this ability. Organisms are constituted from large numbers of basic units (*Cells*). Cells surrounding injured parts can substitute the dead cells and regenerate the damaged structures. Also, the cells themselves can recover from various damages, for instance by repairing their DNA. Furthermore, living organisms *regulate* their physiological parameters to the changing conditions and needs of an organism. As another remarkable property, the *autonomic nervous* system of higher animals controls important bodily functions (e.g. respiration, heart rate, and blood pressure) without any *conscious intervention*. Building complex computer system, such as Future Internet and tera devices-chips, having similar properties is a very complex interdisciplinary problem. However, current state of the art did not lead to a practical *autonomic computing paradigm*. *ANC will allow create FUTURE INTERNET and massively-parallel tera-devices chips, which are complex systems with a dynamic behaviour due to the continuously changing environment (anomalies (faults, failures, attacks, congestion) , traffic loads, power consumptions, device variability) and will be controlled in an “unconscious” reflexive manner.*
- One of the actual great-challenges of the computer industry is to deal with the complexity of the systems. The Autonomic Computing initiative defined the following functional areas as the cornerstone of an autonomic system: self-configuration, self-healing, self-optimization, self-regulation and self-protection. The self-healing property refers to the automatic prediction and discovery of potential failures and the automatic correction to possibly avoid downtime of the computer system. This leads to the vision of ”computers that heal themselves” and do not depend so much on a system manager to take care of. While there has been some interesting work on self- healing techniques or mission-critical systems there is a long way to achieve that goal in the Future Internet.

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- The Future Internet may not be able to achieve its functional goals because of certain anomalies (node and link failures, performance failures and DoS). Such anomalies will be considered as “normal” properties of Future Internet. However, the Future Network may counter these anomalies by protection mechanisms. In many cases, the population can not trust systems processing sensitive personal information to conform to public policies in the realms of health care, banking, e-commerce, and government without fear of sudden disruption by cyber attacks. In particular, the vision motivating Future Internet is to enable scalable, available, secure and transparent resource sharing (data and computing) across a widely distributed dynamic heterogeneous network environment.
- The major autonomic properties self\*(organization, optimization, reconfiguration, healing and protection) that will be guaranteed by Autonomic Network Computing (ANC), will provide uninterrupted service to millions of Internet given event is not tied to one box necessarily or one storage disk. Once you get that kind of leverage, you can build the set of functions that relate to self\*(organizing, reconfiguring, healing, optimizing and protecting.) The new design paradigm that you have to have *holistically* has to deal with the fact that the overall environment is strongly dynamic. The question is how to shield that from the end user to keep the application running. Being able to quickly move workload is a critical vehicle for that. ANC, will be used to provide a *trusted access* to information via the Internet. In order to exhibit *sustainable behaviour* and to be able to quickly react to anomalies, the networked system should be able to predict, based on machine learning techniques, its status or anticipate load or anomalies (failures and attacks).
- ANC will allow to create massively-parallel tera-devices chips, which are complex systems with a dynamic behaviour due to the continuously changing environment (anomalies, power consumptions, traffic loads, device variability) and will be controlled in an “**unconscious**” **reflexive manner**.

# Autonomic Network Computing (ANC)

- Technology scaling has enabled tremendous growth in the computing industry over the past few decades. However, recent trends in power dissipation, reliability, thermal constraints, and device variability threaten to limit the continued benefits of device scaling and curtail performance and energy improvements in future technology generations. The temporal and spatial scales of these effects motivate “holistic “ solutions that span the circuit, architecture, and software layers. ANC proposes a “holistic” solution that encompasses self-monitoring, self-healing, self-regulating, self-reconfiguration and self-optimizing properties of massively-parallel tera-devices chips at different 2 levels of abstraction (from the circuit up to the interconnection&system level). The solution will be accomplished by a novel design paradigm, which is based on the principals of autonomic nervous system (ANS) and is “beyond of the traditional thinking . “
- In order to build tera devices massively-parallel systems in nano-scale technologies, the ANC proposes a new paradigm shift towards autonomic complex systems that continuously use self-monitoring, self-healing, self-regulating, self-reconfiguring, and self-optimizing mechanisms during normal operation in the field, **without external intervention.**
- The interconnection network in autonomic massively-parallel tera-devices chips has a profound effect on their the autonomic properties. *Low-power on-chip interconnection network is needed, or it will be key stumbling block for the realization of tera-devise chips. On-chip interconnection network should not just handle communications, it should drive and shape it.* Key optimization drivers will be the cost-effectiveness of the "**holistic**" approach, and the minimum impact of the solutions on the system performance and power efficiency. The guarantee autonomic behaviour of tera devices silicon chips several challenging tasks must be solved in order the self-properties to be guaranteed.

# Autonomic Network Computing (ANC)

## Impact

The results of this will contribute to the realization of many aspects of the long-term vision in the ICT domain by allowing all ICT users, in all disciplines to use and relay on ANC. This will lead in a long run to a potential high pay-off by restoring and increasing the trust of a large number of users into processing sensitive personal information in the realm of health care, banking, e-commerce, e-science and government. Finally, ANC offers one step ahead to offer more efficient theory to manage the computing resources. ANC will offer a basic platform to achieve greener and more available Internet services because, ANC looks for a better resource management and utilization according to the status of the system. It is not the current main goal of ANS but it is in the long term vision of this theory, which is taking into account the growing up important issue in our society nowadays: *becoming Green Computing systems*.

*Tera-devices* chips with autonomic behavior will achieve unprecedented computing power and may have a profound impact on all computer application domains (internet infrastructure and utilization, network & cloud computing, embedded systems, telecommunication networks, ...), and ultimately on science, technology and the society as a whole.

Work programme topics from FP7 ICT addressed :

- Challenge 1: “Pervasive and Trustworthy Network and Service Infrastructures”
- Objective ICT-2009.1.1.a: “Future Internet Architectures and Network Technologies”.
- ICT-2009.3.6: Computing Systems
- ICT-2009.3.1: Nanoelectronics Technology

## Integration

*Computational Perspective:* **Convergence of Internet and Multicore systems in the future.** The Future Internet will be driven by multicore based modules (blades) for the Data centres and transport layers. Fractal operating systems (FOS) controlling Internet and implemented on multicore systems (tera devices -chips) will drive the Internet.

# Autonomic Network Computing (ANC)

*Mathematical perspectives:* ANC objectives aim to contribute to further development of important scientific areas by formulating new problems to be solved in: algorithm complexity, graph theory, queuing theory, effective learning and prediction, non-linear optimisation techniques and game theory.

*Social Science Perspective :* ANC will drastically increase the level of thrust of the millions users over the world into the Services provided by Internet – e-commerce, e-science, banking .

*Economic Perspective:* ANC will guaranteed significant increase of the availability, QoS and security of the Internet. As a results of this, drastically will be reduced the maintenance and management cost of Internet services for million users and small and big companies over the world.

## Plausibility

- The “*holistic*” approach for ensuring the autonomic properties of the Future Internet and massively-parallel tera devices will be the intellectual focal point of scientist and researches of universities and research labs to collaborative efficiently. The level of complexity of these tasks is extremely high and a single team is not capable of solving them, since the ANC is “*intrinsically interdisciplinary.*” Therefore, the collaboration work will be established for providing higher availability, QoS and security of the Future Internet and massively-parallel tera devices and will be for a mutual benefits of all parties and millions users. ANC will provide *sustainable* services of such large companies in the area of Network/Cloud Computing and Services (Google, Wikipedia, Digg, Amazon) and improve drastically their level of services.

- **Comments :** ( Academic scientists and labs who already occupy this community and are interested in developing the area include) : Technical University of Munich - Germany, Karlsruhe University of Technology – Germany, University of Roma-Italy, Barcelona Supercomputer Center / University of Catalonia – Spain, LAAS CNRS -Toulouse – France, ATOS – Barcelona – SPAIN, IRIANC- Boston- USA, University of Virginia- USA, IRIANC- Munich – Germany, TIMA CNRS – Grenoble – France, Intel – Barcelona – Spain, IROC- Grenoble-France, IBM – Research Haifa, University of Luebeck /Computer Engineering Inst. - Germany, University of Klagenfurt-Austria, University of Messina- Italy, University of Coimbra, Portugal, University of Patras- Greece.