Information Society Technologies

Situated and Autonomic Communications in FET

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Future and Emerging Technologies

DG Information Society & Media
European Commission

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a research initiative in future and emerging communication paradigms and technologies to reshape the way we communicate and interact in 15 - 20 years

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IST - Future & Emerging Technologies

- More exploratory and visionary, high-risk research
  - Helping new IST-related S&T fields and communities to emerge
  - Majority Academic – Research partners
  - Role of Industry
- Complementary to
  - other IST strategic objectives
  - other FP6 'Anticipating S&T needs / frontier research' (new fields / multidisciplinary work)
  - Open scheme: openness to unforeseeable ideas
    - Continuous submission call
    - total FP6 120 M€
  - Proactive initiatives: critical mass where focus is needed
    - e.g. 'beyond robotics', 'complex systems research', "situated and autonomic communications"
    - total FP6 200 M€

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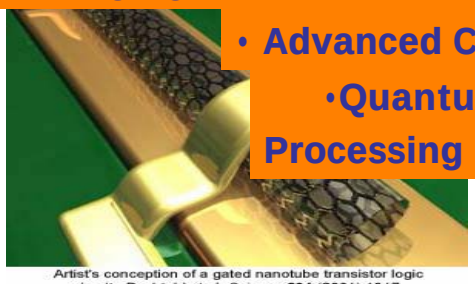
FET Scope and Proactive Initiatives

Components Research

•Emerging Nanoelectronics



Artist's conception of a gated nanotube transistor logic circuit. Bachtold et al., *Science* **294** (2001) 1317.

• Advanced Computing Architectures

•Quantum Information Processing & Communication

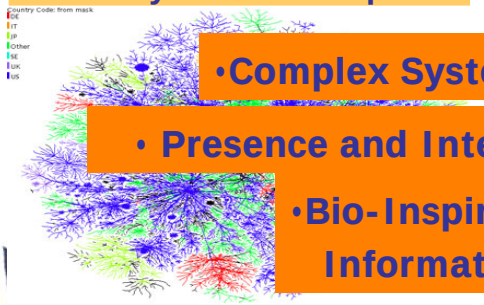
Communications & Computing

•Global Computing

•Situated & Autonomic Communications

•Disappearing Computer

ICT Systems & People



•Complex Systems

Intelligence & Cognition

•Beyond Robotics

• Presence and Interaction in Mixed Reality Environments

•Bio-Inspired Intelligent Information Systems

FET Proactive Initiatives in 4 FP6 Calls - statistics

- 32 projects selected in FET proactive Calls (188 Me, 31 IPs + 1 NoE)
  - Max 4 IPs per initiative
- Statistics on IPs:
  - Partners: 4-35, average 15 (industries: 0-5, average 2)
  - Budget: 4-15 M€, average 7 M€;
  - EC Funding: 3.4 – 10.5 M€, average 6 M€
  - Duration: 4 years for >90% of IPs
- Synopses:
  - http://www.cordis.lu/ist/projects/projects.htm

SAC timeline

- 22 July 2003: First brainstorming meeting
  - "New Communication Paradigms for 2020"
- 3-4 March 2004: Consultation Meeting on "Communication Paradigms for 2020"
  - 45 external experts representing university, industry, telecom operators and research centers
  - Outcome: background document on Situated and Autonomic Communications
- 1 October 2004: Coordination Action on Autonomic Communication (ACCA) start
- 1 December 2004: Call launch (20 Meuro)
- 8 December 2005: Autonomic Communication Forum launch
- 22 March 2005: Deadline for proposals
- 1 August 2005: negotiation of 4 selected proposals (out of 12 submitted)
- 3-5 October 2005: 2nd International Workshop on Autonomic Communication (WAC 2005) - Vouliagmeni-Athens (EL)
- 1 January 2006: start of the selected Integrated Projects (if negotiation successful!)

Communications, Computing, Networking

–Challenges for FET

increasingly high complexity of the internet and demands being placed on it

(complexity = management and maintenance effort)

Situated and Autonomic Communications

Envisage radically new communication paradigms considering simultaneously many technologies, paradigms and approaches, in a long-term economic and social view

Ad-hoc networks

Pervasive, ubiquitous communications & computing

Multidisciplinarity: software, hardware, communications, computing, control theory, formal methods, distributed systems, …

Sensor networks

Vision: a world pervaded by ubiquitous communication facilities self-organising their functionalities without any direct human intervention

Situated and Autonomic Communications

- **Situated Communications:**
  - **Context-Aware (i.e. reacting locally on context changes), "local"**
    - **Ranging from sensor networks to virtual networks of humans**
  - **Considering strategic needs (social or economic, not only technological, e.g. privacy)**
- **Autonomic Communications:**
  - **network elements autonomously interrelated and controlled, learning the desired behaviour**
    - **self-* (organising, managing, evolving, healing, protecting, implementing…)**
    - **radically distributed**
    - **technology independent**
- **Self-organisation needs broad interdisciplinary approach**
  - **software and hardware developments, radio technology advances, design methodology, control theory, formal methods, distributed systems research, complexity theory, game theory, sociology, etc.**

Goal and Objectives

- Goal: communication/networking should become **task-** and **knowledge-driven** and fully scalable
- Objectives:
  - To define a self-organising communication network concept and technology that can be situated in multiple and dynamic contexts
    - **defining decentralised optimisation strategies**
    - **benefiting from cross-layer or non-layered approaches**
  - To study **how** social or commercial **strategic needs impact on future communication paradigms**, and how networks and applications can support society and economy
    - **to develop** networking technologies **(hardware/software combinations)** that can evolve **and create maximal synergy with the other types of non-technological networks that constitute their context**

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Key Requirements

- security and trustworthiness of this distributed communication system
  - **by embedding security and trust rules in network functionality at modelling and design phases**
- overall stability and resilience of the network
  - **as it evolves ("growing not constructing" future networks)**
- positive interactions which the new communication paradigms will have on human and social aspects
  - **in relation to ambient intelligence and more in general to future sensorized societies**

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Situated and Autonomic Communications IPs

IP BIONETS

- **Biologically-inspired approach (from nature and society) to localised autonomic communication services without central control**
- **Allowing high-level services to evolve spontaneously**

IP ANA

- **Novel network architecture (beyond IP) enabling flexible and autonomic formation of network nodes according to working, economic and social needs**
- **Focused on adaptation and self-reorganization of the network**

IP HAGGLE

- **Cross-layer network architecture exploiting intermittent connectivity**
- **exploiting opportunistic networking paradigm (delivery of messages based on store and forward using situated information)**

IP CASCADAS

- **Defining a new generation of highly distributed, pervasive, situation-aware, semantically self-organising communication-intensive services**
- **Focus on self-similarity, autonomic component-ware**

Common research issues:

Security, resilience,

self-* (organisation, evolution, management, healing, …)

interaction of new paradigms with society

The BIONETS Consortium

BIONETS

- CREATE-NET (in cooperation with Univ. Trento and CNR Pisa) (IT)
- Universität Basel (CH)
- Teknische Universität Berlin (DE)
- Hamburger Informatik Technologie-Center e.V. (DE)
- RWTH Aachen University (DE)
- Imperial College London (UK)
- Budapest University of Technology and Economics (HU)
- Valtion Teknillinen Tutkimuskeskus - VTT (FI)
- Institut National de Recherche en Informatique et Automatique - INRIA (FR)
- National and Kapodistrian University of Athens (GR)
- London School of Economics and Political Science (UK)
- Nokia Corporation (FI)
- Telecom Italia Learning Services SpA (IT)
- Sun Microsystems Iberica SA (SP)

Looking for…

BIONETS

A communication system supporting millions of localized services in an environment consisting of billions of heterogeneous nodes, intermittently connected and extremely low-cost

For a P2P Communication Architecture

BIONETS

- T-nodes:
  - only read by U-nodes in proximity

    removing cost/complexity: routing, forwarding, protocol stack
- U-nodes
  - communicate with T-nodes to collect/exchange data
  - communicate with U-nodes
    - exchanging information in a peer-to-peer fashion with other U-nodes on the move running the same service

      exploiting the mobility of U-nodes for connectivity

      connection throughput scale as [TseGrossglauser01]

      act as a gateway to the backbone having the resources

The New Service Paradigm

BIONETS

- **Build the solution on the best example around!**
  - *Adaptation by evolution* **is the way organisms evolved in nature**
- **Make the** *service the organism's epicenter*, **and apply the** *rules of genetics* **and let the process of** *evolution*/*adaptation* **do its job**

BIONETS: BIO-inspired NExt generaTion Services

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ANA Consortium

- ETH Zurich (Coordinator)
- University of Basel (Co-coordinator)
- NEC
- University of Liege
- University of Lancaster
- Fokus
- NKUA
- University Pierre et Marie Curie
- University of Oslo
- Telekom Austria

UNI BASEL

LANCASTER UNIVERSITY

NEC

ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

Fraunhofer Institut für Offene Kommunikationssysteme

NATIONAL & KAPODISTRIAN UNIVERSITY OF ATHENS

LIP6

ULg UNIVERSITÉ de Liège

TELE KOM AUS TRIA

UNIVERSITETET I OSLO

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Motivation and Goals

- The Internet suffers from architectural stress:
  - not ready to **integrate and manage** the envisaged huge numbers of dynamically attached devices (wireless revolution, mobility, personal area networks etc)
  - Lacks integrated **monitoring and security** mechanisms

→ Consensus in the research community that a next step beyond the Internet is needed.

- Develop a novel network architecture that enables for flexible, dynamic and secure **autonomic formation** and **adaptation** of network es and whole networks

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ANA Challenges and Approach

- Identify **fundamental autonomic network principles**
  - **From static global functions/layers to flexible functional (re-)composition (*atomization*, *diffusion*, *sedimentation*)**
  - **For wireless and fixed networks**
- Design **and build an experimental autonomic network architecture**
  - **Preliminary experimental results are used as a feedback to revisit architectural design**
- Demonstrate **feasibility of situated and autonomic networking within oject lifetime**
  - **ANA uses Testbed and Prototypes as investigative research vehicle**

@N

Autonomic Network Architecture

UNIVERSITY OF CAMBRIDGE

EPFL

EURECOM

intel

Martel

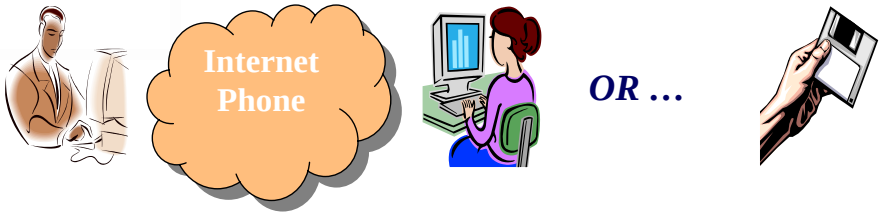
SUPSI

THOMSON

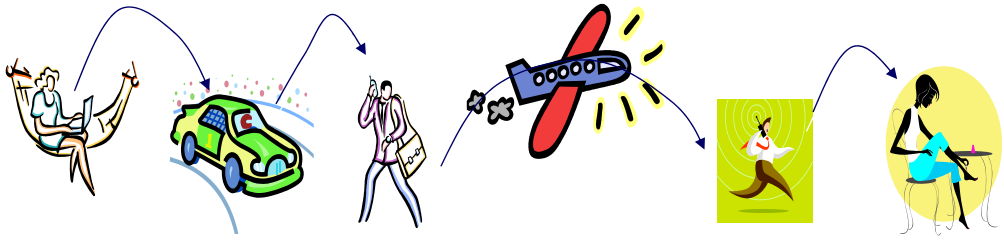
UPPSALA UNIVERSITET

HAGGLE - No alternative to global services

Today



Tomorrow



Haggle

Haggle

- Supports transmissions when end-to-end contemporaneous connectivity is not available, taking advantage of local of global connectivity
- Build on the model of search engines such as Google with no centralized services and no pre-requisite of network connectivity, hence "Ad-Hoc Google“, or HAGGLE

1. Telecom Italia S.p.A. (IT)
2. British Telecommunications plc (UK)
3. Budapest University of Technology and Economics (HU)
4. Fraunhofer Institute for Open Communication Systems (DE)
5. Imperial College London (UK)
6. INSTITUT EURECOM (FR)
7. Politecnico di Milano - Dipartimento di Elettronica e Informazione (IT)
8. National and Kapodistrian University of Athens (GR)
9. Universität Kassel (DE)
10. Université Libre de Bruxelles (BE)
11. Università di Modena e Reggio Emilia (IT)
12. Università degli Studi di Trento (IT)
13. University of Ulster (UK)
14. School of Management of Milano (IT)

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CASCADAS

- The Problem:
  - Resources and Services in the age of computing ubiquity must be able to carry out their increasingly complex functions without significant intrusion into our lives, with ideally no cost of configuration and complexity
- The Goal:
  - define the underlying technology for a new generation of composite, highly distributed, pervasive services, that addresses these configuration and complexity problems.
- The main Challenge:
  - identify, develop, and evaluate a general-purpose abstraction for autonomic communication services, in which self-similar components autonomously achieve self-organization and self-adaptation towards the provision of adaptive and situated communication-intensive services.
  - this abstraction is called ACE (Autonomic Communication Element) and represents the unifying framework for all project activities
  - ACE will become the enabler for a self-organizing communication network

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CASCADAS

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FET: Key points

- **FET is about High-Risk, Visionary research, exploring new concepts**
- **IPs have a different aim than in the rest of IST and should not duplicate other areas**
  - **e.g. *Broadband for All* and *Mobile and Wireless Systems and Platforms Beyond 3G***
- **Mainly univ. participation, industry welcome**

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2020: Where are we going?

- Billions of nodes, information explosion
- Decentralised and autonomous operation, distributed control
- Situated services, exploiting « local » information
- Self-everything: Self-organisation, but also self-ishness
- Multiple approaches:
  - Deterministic
  - Bio-inspired
  - Stochastic
- "all exact science is dominated by the idea of approximation " (Bertrand Russell)

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Open questions

- Sophistication or KISS?
- Selfishness of distributed nodes expected to cooperate.
  - Is it unavoidable? Would social models work?
- Security. Every mutation in nature is breaking the DNA security rules.
  - Is it possible to have 100% security in really self-evolving networks?
  - Do we have to conceive security on a different scale?
  - Is bio-inspiration an inherently stochastic approach?
- Disappearing trend.
  - The computer, the interface, the network operator…
- Need to involve more other disciplines:
  - Physics (statistical models, dynamic systems, percolation, chaos theory, etc.)
  - Social sciences (human psychology, behavioural studies, social models – philosophers?)
  - Mathematics (applied to social systems)
  - Economics (economic models, incentives, etc.)
  - Women!

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For further information

IST:

http://www.cordis.lu/ist

FET:

http://www.cordis.lu/ist/fet

http://www.cordis.lu/ist/fet/comms.htm

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