



IST Mobile Summit

BIONETS: Don't Reinvent Nature, Just Go For It

Daniele Miorandi

CREATE-NET

Trento (IT)

daniele.miorandi@create-net.org

www.bionets.org

Mykonos, 7 June 2006

Motivation & Constraints

THE SCENARIO

- ▶ Pervasive computing environments: an ubiquitous halo of devices with sensing/identifying capabilities for personalized context-aware services

A TRILOGY OF CHALLENGES

- ▶ *scalability*: billions of nodes, a multitude of users and services
- ▶ *heterogeneity*: at the device and service level
- ▶ *complexity*: management of a large-scale heterogeneous mobile network, provisioning of consistent and secure service operations

The Failure of Conventional Approaches: Some Details

ISSUES CALLING FOR NOVEL SOLUTIONS

- ▶ Connected networks do not scale (Gupta & Kumar, TIT00). Need to support disconnected operations. *From always-on networks to à la carte ad hoc network support to services*
- ▶ Impossible to use a unique global address space. Need to look for novel solutions (attribute-based naming?): *from address-based architectures to context-based architectures*
- ▶ Need for extremely cheap long-lasting sensor nodes. Clashes with the hourglass “one-size-fits-all” model. Need to *exploit heterogeneity in multi-tier architectures*
- ▶ How to manage my network (large-scale, disconnected, mobile)? *From central control to distributed autonomic operations*

The Very Basic BIONETS Ideas

LEARNING FROM EXAMPLES

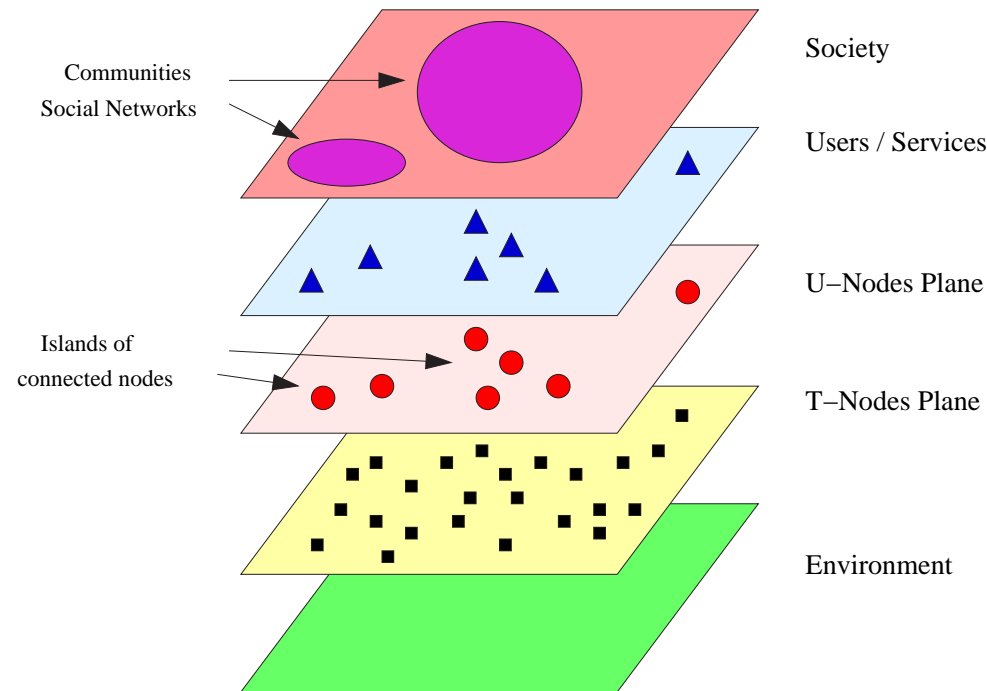
- ▶ Pervasive environments will present scale and complexity figures not far from those typical of biological/socio-economical systems
- ▶ These 3 issues (heterogeneity, scalability, complexity) already successfully tackled by *Nature & Society*
- ▶ Plenty of examples of biological/socio-economical systems able to reach efficient equilibria in a simple, *autonomic* fashion, without any external control
- ▶ The bottom line: draw inspiration from nature to build a distributed autonomic system based on local interactions

BIONETS Foundations

THE BIONETS VISION

- ▶ Overcome device heterogeneity and achieve scalability via an autonomic and *localized peer-to-peer communication paradigm*
- ▶ Services are autonomic, and *evolve* to adapt to the surrounding environment, like living organisms evolve by natural selection
- ▶ Network operations will be driven by the services, providing an ad hoc support when and where needed to fulfill users requests
- ▶ The network will become just an appendix of the services, which, in turn, become a mirror image of the social networks of users they serve

BIONETS at a Glance



The large-scale BIONETS project picture. Tiny nodes (T-Nodes) gather data from the environment and are read by user nodes (U-Nodes) in proximity. U-Nodes form islands of connected devices and may exchange information when getting into mutual communication range; decisions are taken by the service itself. Services are user-situated, and their interactions reflect the social networks/communities users belong to.

The BIONETS Pillars

- ▶ The BIONETS project builds on two pillars, dealing with networks and services. They will converge to provide a fully autonomic environment for networked services
- ▶ (i) *Disappearing network*: a novel approach to information diffusion, communication and filtering, replacing E2E Internet approaches with *localized service-driven communications*
- ▶ (ii) *Self-evolving services*: a bio-inspired platform, centered around the concept of *evolution*, for the support of autonomic services life-cycle



Evolution in BIONETS

THE SERVICE SIDE

- ▶ The concept of “evolution” in BIONETS builds on the notion of *self-organization*
- ▶ Socio-economical processes are envisioned as the factors able to provide the “free energy” necessary to “decrease” the entropy of the system and build order
- ▶ Evolution in BIONETS is considered at two levels: single components and global ecosystem
- ▶ At the component level, each service will be able to *design and build* its own protocol stack (and, in some sense, its own network): from self-assembling Lego-like protocol components up to gene expression models for self-generation of code
- ▶ At the system level, interactions among service entities will provide the means for services to evolve rapidly (“service mating”) while maintaining global stability properties (Evolutionary Stable Strategies)

Any Example?

A GPS-BASED CAR NAVIGATION SYSTEM

- ▶ Metropolitan scenario
- ▶ Sensors used to control the state of parking lots, monitor traffic etc.
- ▶ Cars movement use to spread information on the actual state of the system
- ▶ User interested in finding a free parking close to her/his destination
- ▶ Currently, use of traffic message channel + shortest path on a weighted graph (but no parking support)
- ▶ Evolution of the path computation algorithm to account for user preferences/feedback and state of parking lots

Wrapping up ...

THE BOTTOM-LINE

- ▶ No need to reinvent the wheel: possible approaches to tackle S&AC are already out there on the ground (literally)
- ▶ Every kind of inspiration is allowed in science: building working solutions is the real issue
- ▶ When looking for *design rules* for large-scale complex systems, go for biology as the best area to draw inspiration from
- ▶ Looking at the future: need to form a new class of young researchers with cross-disciplinary competences, able to keep EU at the cutting edge of research in S&AC field