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BIONETS

Running Services in a Disappearing Network: Anything to Learn from Nature?

Daniele Miorandi
CREATE-NET
Trento (IT)
daniele.miorandi@create-net.org
www.bionets.eu

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BIONETS: 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 More 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 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 data-centric architectures*
- Need for extremely cheap long-lasting sensor nodes. Clashes with the hourglass "one-size-fits-all" IP model. Need to *exploit heterogeneity in multi-tier architectures*
- How to manage my services & networks (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 succesfully 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

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

Supporting BIONETS Services

THE NETWORK SIDE

- Devices classified in two categories. T-Nodes, simple and cheap, acting as a distributed interface to the physical environment. U-Nodes, complex portable devices, carried around by users in their daily life
- A two-tier architectures. T-Nodes “read” by U-Nodes in proximity. U-Nodes run services in a cooperative distributed fashion
- BIONETS services build on the limited connectivity offered by U-Nodes
- Interactions among devices driven by the services, which can build on-the-fly the networking support (e.g., protocol stack) they need

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 (micro) and global ecosystem (macro)
- 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)

Conclusions

SUMMARIZING . . .

- BIONETS looks at nature and society for introducing novel networking/service provisioning paradigms tailored to pervasive computing environments
- Introduces a design shift: from performance-oriented systems to design for robustness and resilience
- Exploits opportunistic communications as a mean to provide a localized support to self-evolving services

POSSIBLE SPIN-OFFS OF BIONETS PATHFINDER

- Self-assembled protocol stacks (in particular: transport protocols)
- Bio-inspired mechanisms for service-driven network self-management
- Biology as a “safe basis” for constructing evolve-able and future-proof pervasive ICT systems