Panel:
Building the Internet of the Future
The Wireless Challenge

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IEEE PIMRC 2008, Cannes, France, September 2008

Challenge

- Challenge
  - Function: noun
  - Date: 14th century
- 1:
  - a: a summons that is often threatening, provocative, stimulating, or inciting; specifically: a summons to a duel to answer an affront
  - b: an invitation to compete in a sport
- 3: a stimulating task or problem
  <looking for new challenges>

The David Goodman Challenge (16/09/2008)

… and my response

- The Emerging Internet
- The Wireless Advantage (of the Internet) rather than the Wireless ***Challenge***…
- mobility improves performance
- additional nodes
  - add BW
  - save energy
- self-organizing
- inter-operating
- optimized to specific requirements
- a lot of Internets
  - Health applications

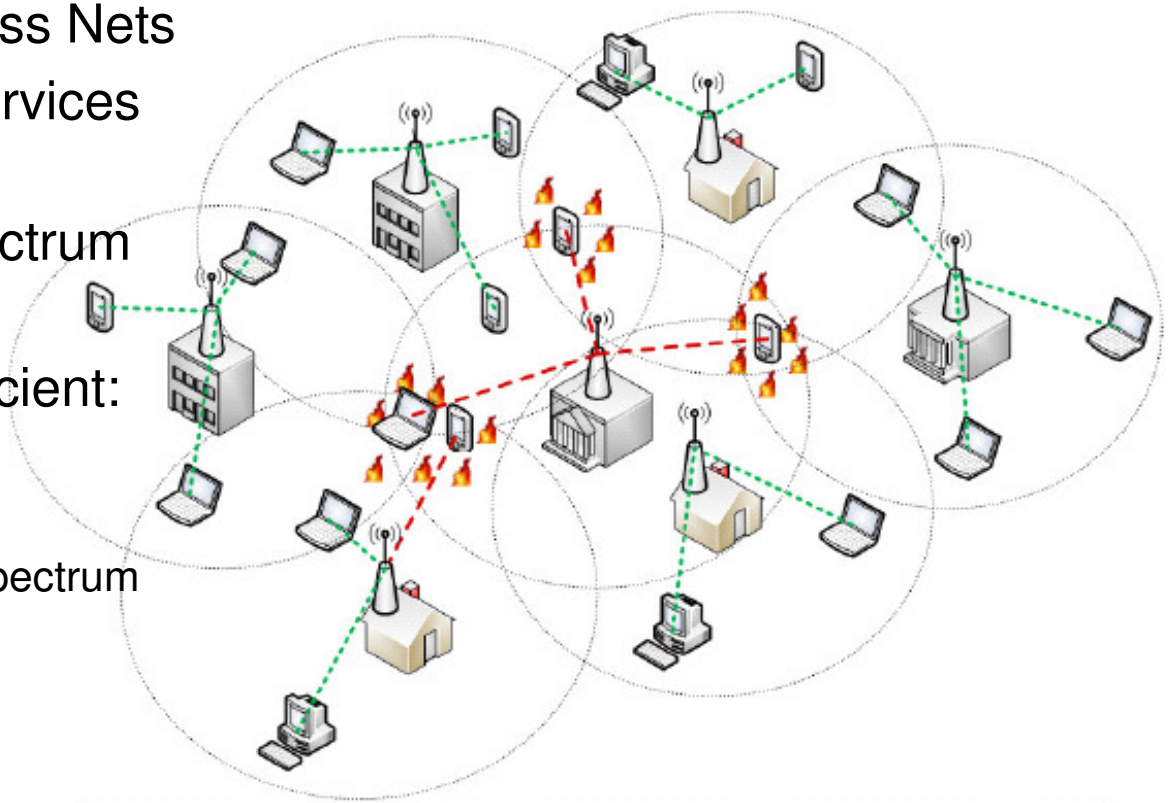
- … Wireless Community Networks
  organic growth…
- The Challenge to build the Internet of the future so that Wireless, Mobility, Security are not afterthoughts…
  - FP7/ICT PSIRP
- agree on all those

… and incorporated into design…

  - e.g. P2PWNC
- freedom & incentives for cooperation…
- **1** Internet (@ levels of functionality?)
  - PDAs & WSNs for health support

Emerging Wireless Internet & Open Spectrum Access

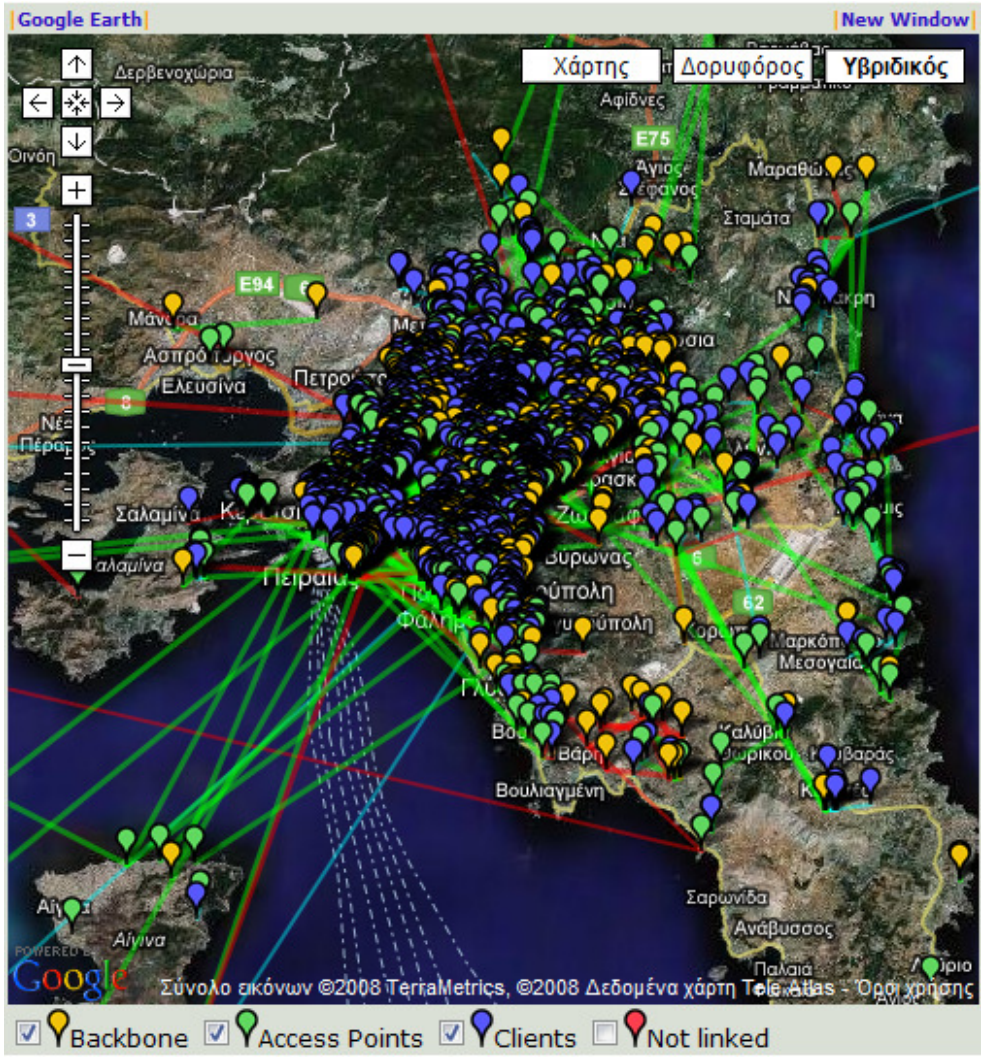
- **Organic growth** of Wireless Nets
- Proliferation of wireless services & devices
- Increased demand for spectrum
  - Regulation …
- Traditional approach inefficient:
  - Licensed bands:
    - temporal & spatial underutilization of the spectrum
    - low BW/high cost
  - Unlicensed bands:
    - interference
    - limited coverage
  - The Role of Cognitive Radio / Networks



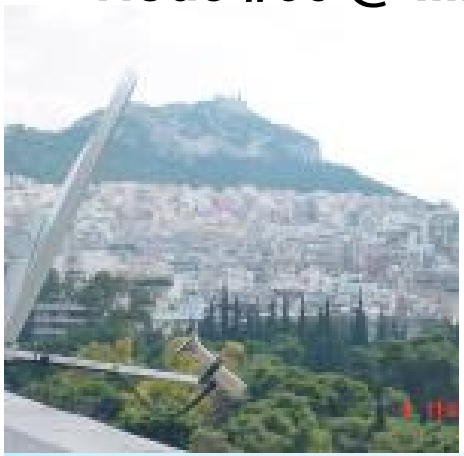
Wireless Community Networks…

Seattle Wireless	**Seattle, US**	**75 nodes**	**Mesh**
AWMN	**Athens, GR**	**2331 nodes**	**Mesh**
CUWiN	**Urbana, US**	**48 nodes**	**Mesh**
Berlin's Freifunk	**Berlin, DE**	**316 nodes**	**Mesh**
NYCWireless	**NYC, US**	**149 nodes**	**Hotspot-based**
Wireless Philadelphia	**Philadelphia, US**	**15 miles^2**	**Hotspot-based**
FON	**Worldwide**	**~210 000 registered APs**	**Hotspot-based**

Athens Wireless Metropolitan Network



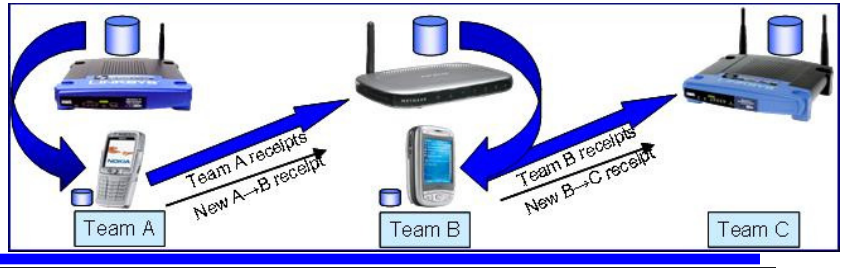
- **among the largest, globally**
  - **2331 active nodes**
  - **2786 links**
  - **791 active services**
- **Node #66 @ MMlab**



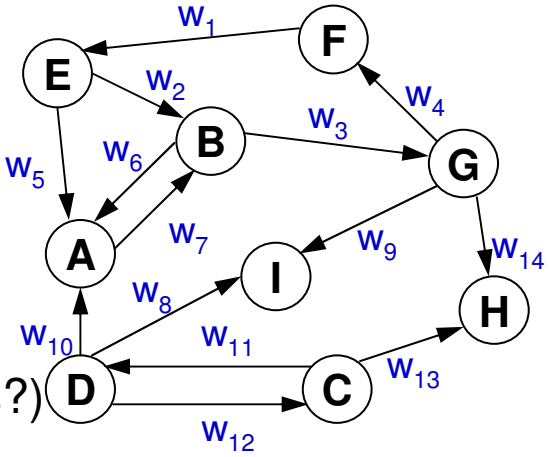
Alternative Spectrum Utilization Model …

- Unlicensed spectrum
  - Anyone can become an operator
    - Low entry cost
      - Increased coverage (@ broader BW, lower cost)
    - Residential WLAN owners, (W)ISPs, 3G operators, municipalities, etc.
    - No inter-operator priorities, in principle!
  - Increased competition
    - Wider service offerings
      - Subject to operator interactions and not user priorities
    - Increased interference $\Rightarrow$ sensing, mitigating
  - Privacy, Security, Trust…
- Open access
  - Without any form of prior contract (subscription)
  - Getting (buying?) network access in small quanta

Peer-to-Peer Wireless Access Sharing



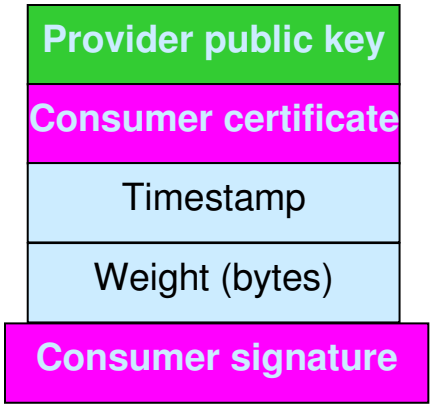
- P2P Wireless Network Confederation (P2PWNC)*
  - A WLAN sharing community
- Rely on (indirect) reciprocity
  - Users set up their APs for public access
  - Get access to other peers' APs when mobile
  - Access and QoS proportional to their contribution



- Authority Distributing IDs (distributed?): trivial… (scales?)
- No central authorities: hard
  - Users identified by self-certified public-private key pairs

- Accounting based on the exchange of digital "receipts"
  - Receipt: proof of transaction signed by client
  - Distributed accounting: each peer stores receipts

- Implemented on common WLAN equipment
  - Linux-based AP, Smartphones, PDAs



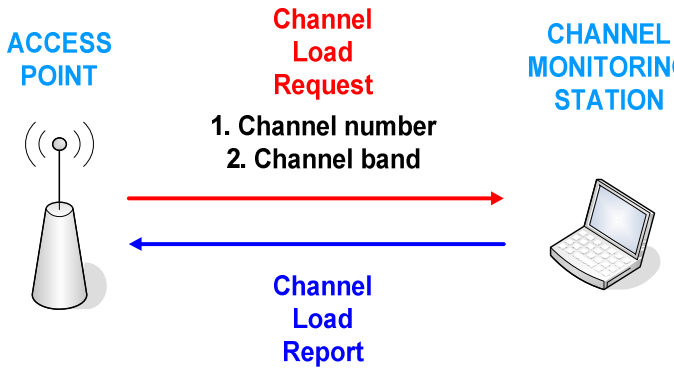
* E. C. Efstathiou, P. A. Frangoudis, and G. C. Polyzos, Stimulating Participation in Wireless Community Networks, IEEE INFOCOM 2006, Barcelona, Spain, April 2006.

Dealing with Interference

- Interference control
  - power control, directional transmission
  - channel selection/assignment/suggestion
- Interference detection (across bands and technologies)
  - Access Point-centric schemes
    - Sense spectrum usage at the AP site
      - Easier to control/manage
      - May require additional interface (for channel monitoring)
    - Fail to capture interference beyond the AP
      - Hidden terminals
  - Client-based schemes
    - Clients periodically monitor channel usage
      - Report to APs (or other control entity)
      - Reveal more information, capture user-perceived interference
      - **Cooperation** in determining the interference map…
    - Trustworthy reports?
    - Monitoring overhead? ***Incentives!***
  - Express/Ad hoc sensing devices/sensors

Open Issues in Interference Detection

- Security and reliability
  - How to spot fake reports?
  - Use a client reputation scheme, punish/reward?
  - Use monitors/sensors
    - Where to place them?
    - How many? Who owns/deploys them?
- Model and study incentives mechanism
  - Intuitively, no strong incentive to cheat…
    - …but, still, needs to be proven



IEEE 802.11k

- The **ASPECTS** project: Agile SPECTrum Security
  - Euro-NF (NoE) Specific Joint Research Project
    - AUEB, Blekinge Institute of Technology (M. Fiedler), Universität Passau (H. de Meer)

- Smart monitoring/reporting
  - Optimize monitoring time, energy etc.
  - Ask each client to scan a subset of the channels/spectrum
    - Will reduce scanning time
    - Cooperative scheme / build interference maps
      - Who has the picture? Partial?

PSIRP
PUBLISH-SUBSCRIBE
INTERNET ROUTING
PARADIGM

Hypothesis: Clean-Slate Design Required

- What stood at the beginning
  - Collaboration
  - Cooperation
  - Endpoint-centric services

  does not seem enough
- What about:
  - Trust?
  - Information centrism?
  - Legitimacy of E2E?
  - Role of overlays?

Clean-slate design…

- Question ALL fundamentals
- Challenge our thinking
- Take nothing for granted, including industry structures
- Clear vision

…with late binding (to reality)

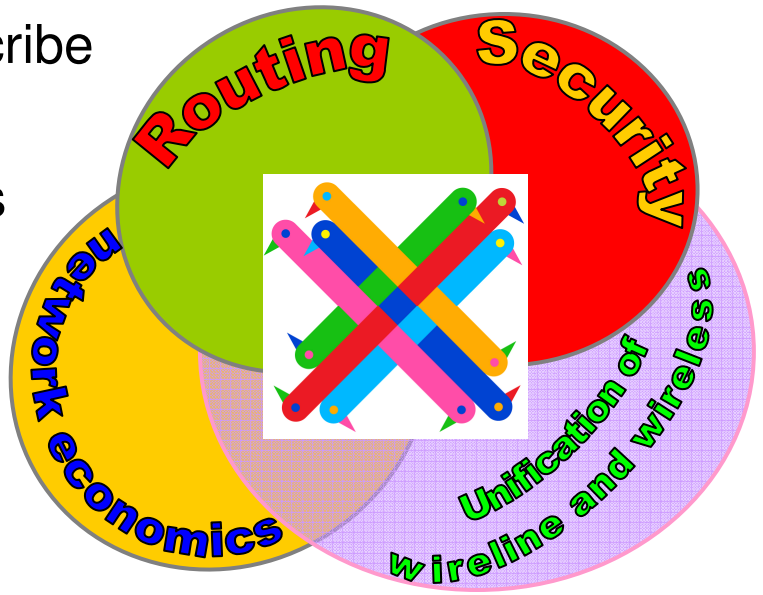
- Consider migration and evolvability in separate work items
  - How to get our design into real deployments, e.g., overlay vs. IP replacement?
- Consider necessary evolution of industry (and regulatory) structures
  - How do industries need to evolve in certain scenarios?

PSIRP
PUBLISH-SUBSCRIBE
INTERNET ROUTING
PARADIGM

Vision

Envision a system that dynamically adapts to evolving concerns and needs of its participating users

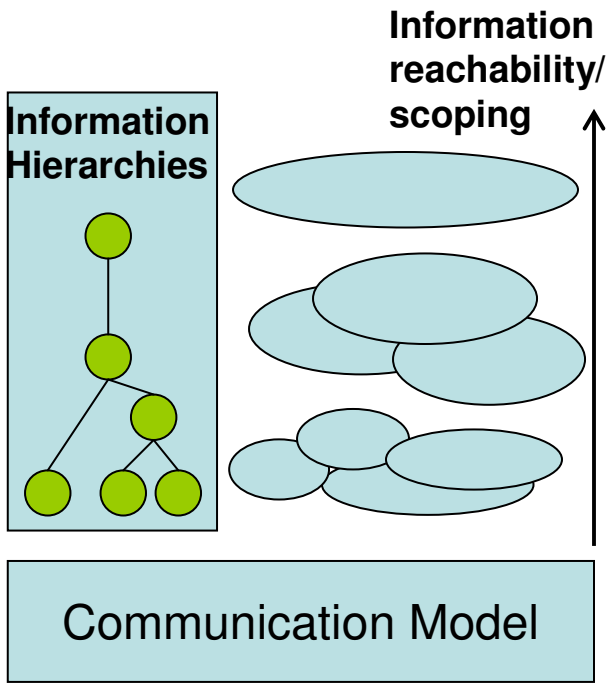
- Publish–subscribe based internetworking architecture restores the balance of network economics **incentives between the sender and the receiver**
- Recursive use of publish-subscribe paradigm enables dynamic change of roles between actors



PSIRP
PUBLISH-SUBSCRIBE
INTERNET ROUTING
PARADIGM

Main PSIRP design principles

- Information is multi-hierarchically organised
  - Higher-level information semantics are constructed in the form of directed acyclic graphs (DAGs), starting with meaningless forwarding labels towards higher level concepts (e.g., ontologies).
- Information scoping
  - Mechanisms are provided that allow for limiting the reachability of information to the parties having access to the particular mechanism that implements the scoping.
- Scoped information neutrality
  - Within each scope of information, data is only forwarded based on the given (scoped) identifier.
- The architecture is receiver-driven
  - No entity shall be delivered data unless it has agreed to receive those beforehand, through appropriate signalling methods.



Project Objectives

- Specify, implement and test an internetworked pub/sub architecture
  - follow a **clean-slate design** approach
- Perform qualitative and quantitative evaluation
  - **Security and socio-economics important!**
  - Migration and incentive scenarios important (e.g., overlay)!
- The results will be widely published
  - Open source code for the Future Internet
  - Targets specifically SMEs opportunities in Future Internet
- Engage with FI community
  - **Cooperate with FIRE (OneLab2) to test on large scale**
  - Engage openly through public Wikis

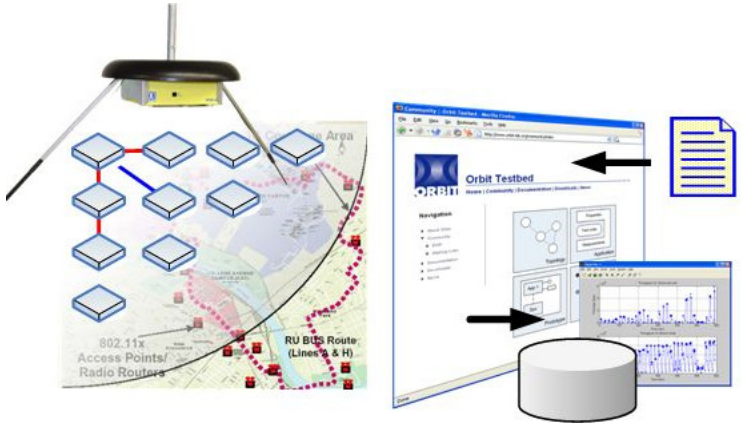
OneLab2

- An Open *Federated* Laboratory
  - Supporting Network Research
    - for the Future Internet
  - Coordinator: Prof. Serge Fdida, UPMC Paris
- built on *PlanetLab* Europe
- enhances the testbed-native network monitoring service
- pilot projects that are potential customers of the testbed
- e.g., PSIRP plans to have application trials on OneLab2
  - Dr. Dirk Trossen, BT
- FIRE: *Future Internet Research & Experimentation*
  - FIRE Expert Group

The Need for Large-Scale Shared Testbeds

- PSIRP
  - Pub/sub, overlays, multicast
  - Beyond simulations
    - OneLab2: ideal environment for experiments

- Wireless research
  - How to experiment with new Open Spectrum Access schemes?
  - FIRE: Future Internet Research & Experimentation
    - OneLab2
  - ORBIT (NSF funded)
    - http://www.orbit-lab.org
    - A grid of ~400 IEEE 802.11a/b/g nodes
  - Issues and limitations
    - Interference →only one,
      or limited # experiments at a time
    - MAC-layer modifications?



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