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Rethinking Wireless Network Design, Management and Operation

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Challenges in Wireless Networks

• A dramatic increase in demand for radio spectrum in future
  – Data transferred in 2009 was nearly ten times as large as in 2007
  – The number of NEs will grow fast (Gupta&Kumar'00)
  – A huge number of wireless devices will become integrated into physical objects and linked through wireless networks (Internet of things, M2M …)

➢ Low-complexity, autonomous, architecture-less wireless networks

• Wireless network management faces unprecedented challenges
  – Release dependence from manual control, adapt to the mandate for autonomous management, realize resource-efficient feedback control…

• Efficient wireless network operation faces fundamental challenges
  – gigantic amount of (sporadically) generated data, limitations on underlying spectrum and other resources, obstacle of interference regimes, energy consumption, reliability, privacy and trust …
Paradigm shift

- Current network management methods will be inadequate to cope with the growth of autonomous (NE). They must account for
  - Unreliable network state information of limited accuracy
  - Possibly conflicting and abstractly defined objectives

- The development and commercialization of many types of wireless networks have been stunted by the lack of a theoretical framework for analyzing and designing MANETs
  - Current information theory ignores bursty traffic, finite flows/sessions, queuing delay and a considerable amount of overhead.
  - Wireless networking theory ignores the interference structure and does not fully utilize to the broadcast property of wireless networks.

 Paradigm shift in network design and management/operation is needed to prevent a slowdown in network development.
Wireless Network Management

• Create awareness at the level of autonomic network elements:
  – Learn and reason through sensing, observing, data exchange, probing, and information extraction based on inaccurate, unreliable data.
  – Improve accuracy through intelligent feedback collection, efficient consensus algorithms and sophisticated information fusion techniques

• Incorporate awareness into the network management control loop:
  – Cope with partial, inaccurate or delayed state information
  – Overcome the obstacle of conflicting network management objectives

• Merge computation and wireless communication: exploit the broadcast property
Wireless Network Control/Operation

• Envisioned wireless networks mandate epistemic approaches to wireless network control, state acquisition and prediction of operating points.
• Fresh ideas and tools, and a think-outside-the-box approach.
• A novel, clean-slate approach is needed:
  – Combine game theory, control theory and information theory.
  – Encompass the notion of information.
  – Bridge the gap between content/application semantics and the communication infrastructure/operating protocols.
  – Understand cooperation and the full range of behavioral profiles.
  – Exploit interference structure and the broadcast property.
  – Embrace context awareness and feedback control.
  – Use efficient consensus algorithms and sophisticated information fusion techniques, merge computation and communication
  – Capture the role of side information.
  – ...

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„It is dangerous to put limits on wireless”

G. Marconi
Nobel prize winner 1909