Panel Discussion on "Carrier Grade Mesh Networks"

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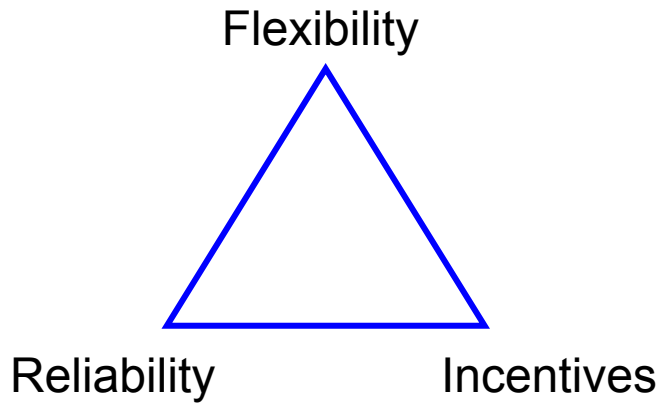
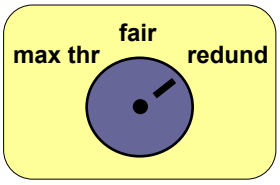
EU-MESH: Enhanced, Ubiquitous, and Dependable Broadband Access Using MESH Networks
FP7 ICT-215320 - www.eu-mesh.eu

Three issues that I consider key to design and operation of wireless access networks:



Flexibility

- Network's ability to operate with different target objectives or goals, e.g.
  - maximize throughput
  - fairness
  - redundancy



- Different from self-configurability, self-management, self-healing
  - self=automated, single target objective
- Flexibility also refers to aspects such as deployment flexibility (e.g. mesh networks)

Flexibility: Why?

- Different providers ⇒ different operation objectives/policies
- Different applications ⇒ different requirements
  - Failed many times to predict future apps
- Economics: Same infrastructure/system components used to build different networks
- Throughput not always most important
  - Availability & consistency can be more important
  - Even if we improve thruput >20%, let alone 1% !

Flexibility and Open Systems

- Flexibility also important from industrial perspective
- Open access networks can trigger innovative applications
- Vyatta, Cisco, and Juniper open router OS
- Open mobile OSs: Apple's iPhone, Google's Android, Nokia's Symbian, LiMo

android

LiMo Foundation

SYMBIAN

Reliability

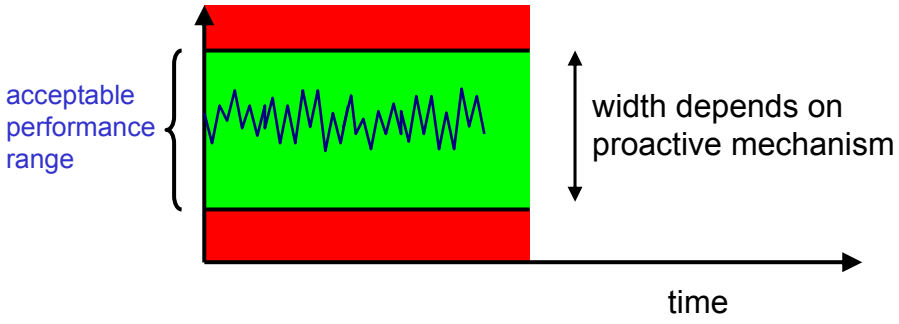
- Reliability: ability to offer continuous service in ***time*** and ***space***
  - third dimension: traffic mix (robustness)
- Availability: percentage of time service is available

Both are part of

- Dependability: ability to deliver service with expected performance or quality

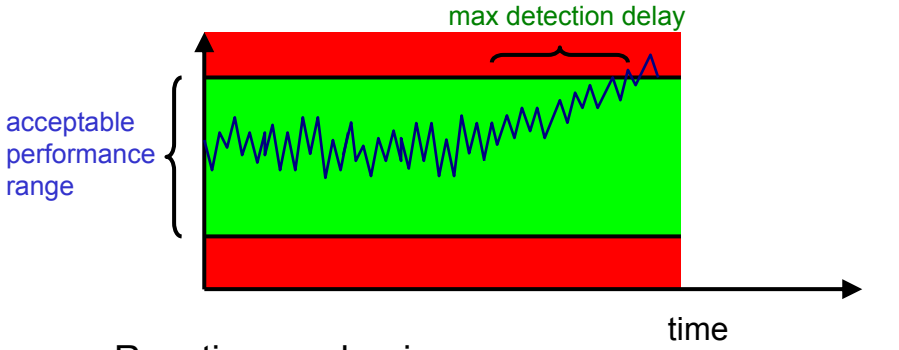
- Not simply identify as a property, but take into account in both design and evaluation

Proactive Mechanisms for Reliability

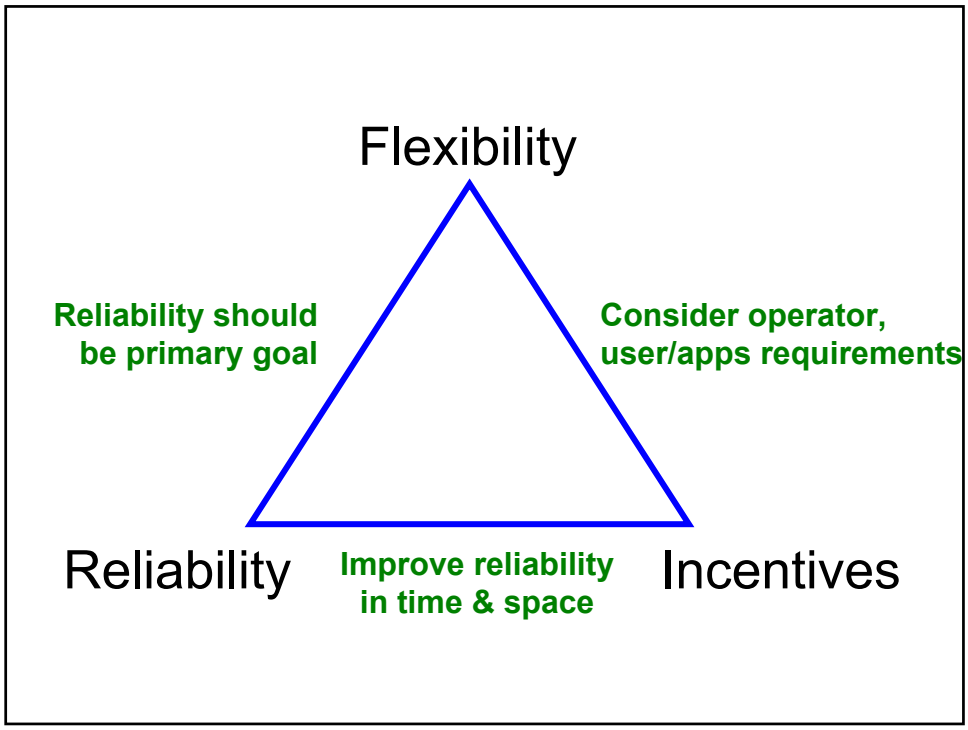


- Proactive mechanisms add redundancy
  - multipath (path diversity)
  - coding (redundancy in transmitted bits)
- Need more resources (overprovision)

Tradeoff between Proactive and Reactive

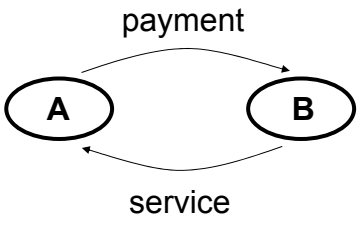


- Reactive mechanisms
  - Detect failure/attack
  - Mitigate
- Tradeoff between acceptable performance range and detection delay



Enforcing Cooperation

- Economic model: Who pays whom for what



- Payment: actual/virtual money, credits, etc
- Reputation/tit-for-tat schemes: similar model, payment=service offering
- Cooperation enforced: explicit connection between service and payments & penalization

Performance-oriented Incentives

- Induce cooperation through improved performance incentives
  - user gains if he cooperates
- Advantage: no need for explicit enforcement or connection between “giving” & “receiving”
- Advantage: A user gains if he unilaterally acts
  - not necessary for all users to act

- Q: Is mesh a successful technology in the market place?

- A: Mixed experience, bad in some cases
- But, features of mesh technology can be key in future wireless/mobile systems
  - wireless multi-hop ⇒ cost & time-effective, increased throughput compared to single-hop, reduced interference & EMF radiation
  - multiple paths ⇒ reliability

- Q: Is there a demand for heterogeneous mesh networks?
- Answers:
  - Similar Q/A for UMTS/LTE radio interface
  - Related to standardization/competition
  - Mesh/multi-hop & multi-path can be key in different heterogeneous technologies, e.g. home mesh networks, dynamic spectrum access

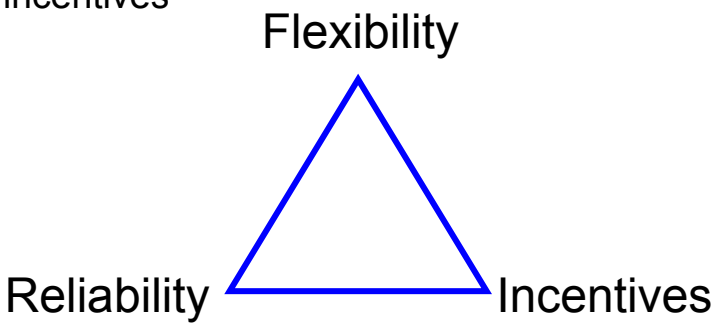
- Q: Is it feasible to provide carrier grade services with mesh networks?
- A: Key feature of mesh is multi-path, which is important for providing reliability/dependability
  - Can play important role in future LTE/WiMax
  - To exploit multi-path need: self-healing, anomaly detection

- Q: Number of wireless hops
- A: 2-3 hops max, limit due to throughput reduction and # radio interfaces in one node
  - these are sufficient to support multiple paths

- Q: Services enabled by mesh technology
- A: cost- and time-effective deployment $\Rightarrow$ ubiquitous access.
  - this helps new/small players enter market, these new players will create innovative applications

- Q: Business models, network operation
- A: coverage of specific area can be cost-effective, hence can be owned by one operator
  - Ubiquity can be improved through cooperation
  - Incentives for cooperation between different operators/users, aside monetary incentives based on cooperation agreements, very interesting

- Q: What are the remaining key challenges to be solved in mesh networks?
- Already mentioned some: flexibility, reliability, incentives



What influences these challenges

- Higher capabilities of mobile devices
  - together with open mobile OS open new opportunities (startups and research)
  - intelligent access network selection
  - intelligence in mobile devices will trigger intelligence in access networks
- Dynamic spectrum allocation / software defined radio
  - increase degrees of freedom (frequency, bandwidth)
  - intelligent mechanisms even more important
  - opportunistic access ⇒ incentives

What influences these challenges (cont.)

- Networks are getting bigger: need scalability but with *strong locality*
  - interference has locality
  - many applications (not all) have locality
  - free white spaces have locality

… so key challenge is

- how to better exploit locality to design more scalable architectures & systems

(e.g. prefix-based, locality-sensitive hashes)

- incentive-based: self-interested users contribute

Final remark

Ask not

- “What is the right business model for mesh networks”

But rather

- “How can mesh technology be used for building better access networks
  where better=more (flexible | reliable | cost effective)