

Panel Discussion on “Carrier Grade Mesh Networks”

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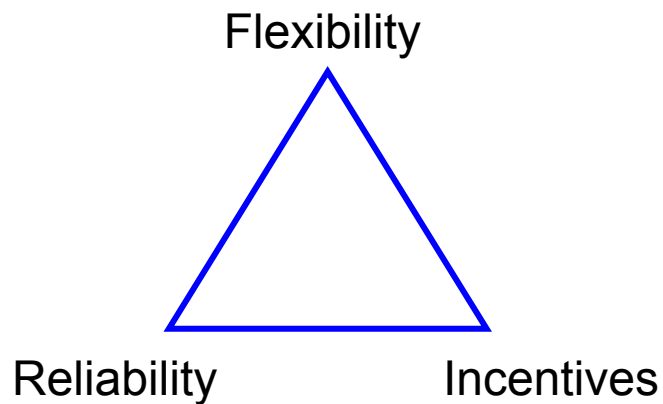
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EU-MESH: Enhanced, Ubiquitous, and Dependable
Broadband Access Using MESH Networks
FP7 ICT-215320 - www.eu-mesh.eu

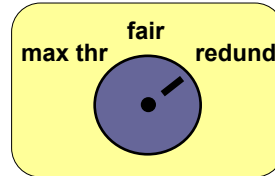


Three issues that I consider key to design and
operation of **wireless access networks**:



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



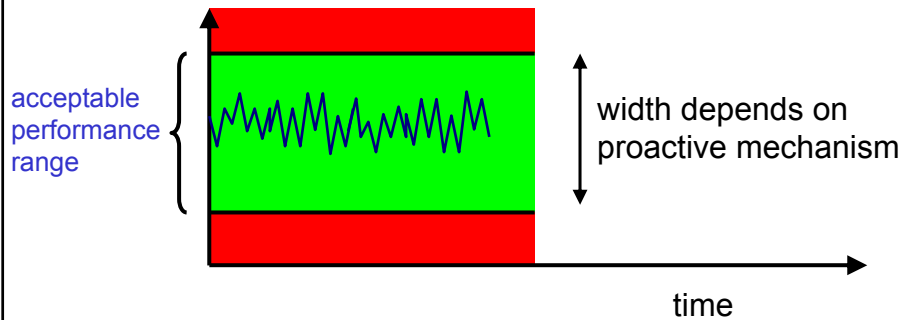
Reliability

- **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

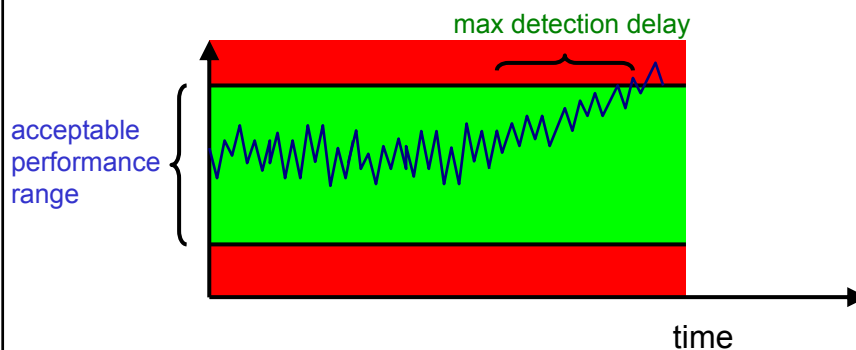
- **Dependability**: ability to deliver service with expected performance or quality
- Not simply identify as a property, but take into account in **both design** and **evaluation**

Proactive Mechanisms for Reliability

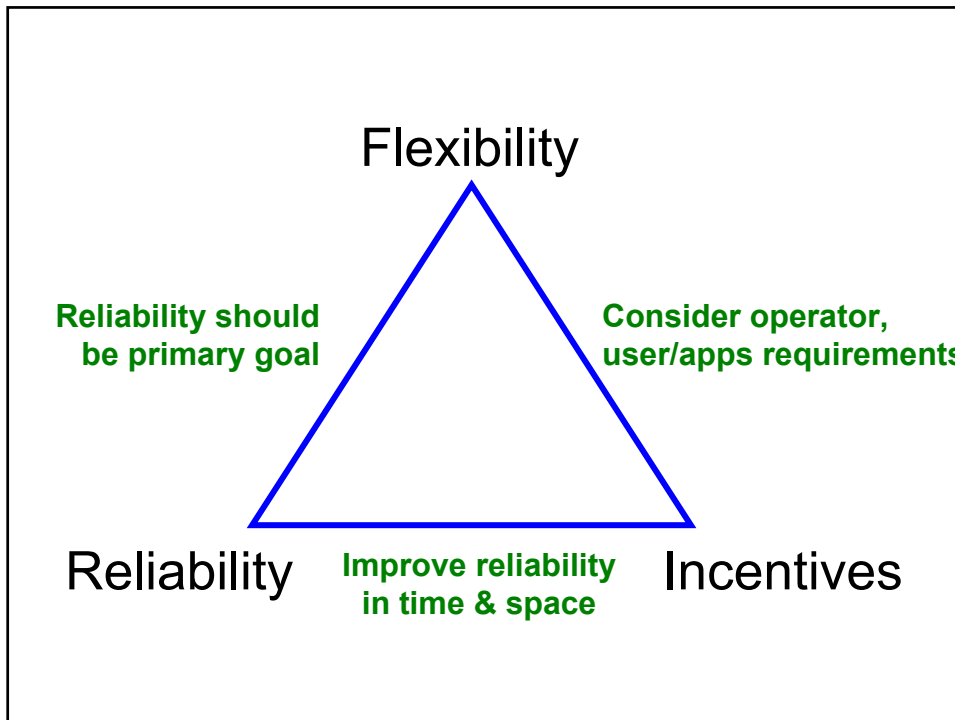


- Proactive mechanisms add redundancy
 - multipath (path diversity)
 - coding (redundancy in transmitted bits)
- Need more resources (**overprovision**)

Tradeoff between Proactive and Reactive

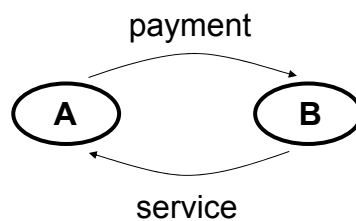


- Reactive mechanisms
 - Detect failure/attack
 - Mitigate
- Tradeoff between **acceptable performance range** and **detection delay**



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

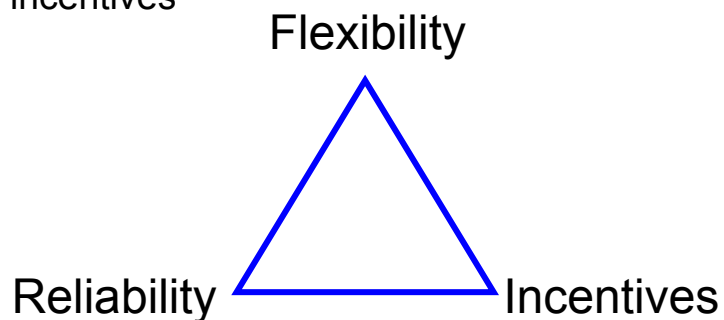
- Q: Is it feasible to provide carrier grade services with mesh networks?
- A: Key feature of mesh is **multi-path**, which is important for providing **reliability/dependability**
 - Can play important role in future LTE/WiMax
 - To exploit multi-path need: **self-healing, anomaly detection**

- 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 ⇒ 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)”