Decentralized Internet Infrastructure
Overview of Potential Use-Cases and Drivers

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Terminology issues

**Decentralized**
* A distributed network of centralized networks.
* Stability: Finite points of failures.
* Management: Coordination of “head” nodes
* Scalability: Moderate
* Heterogeneous: Moderate

**Distributed**
* Each node is connected to various other peer nodes
* Stability: without single point of failure
* Management: Self-x
* Scalability: high
* Heterogeneous: High.

Copyright: Paul Baran (1964)
Motivation

Need for Decentralization/Distribution

**Avalanche of Mobile Broadband**
- Expansion of traffic volume
- Multi-tenant control
- Robust Mobility management

“1000x in ten years”

**Massive growth in Connected Devices**

- Internet of Things
- Density control
- Diversity control

“50 billion devices in 2020”

**Large diversity of Services & Applications**

- Internet of People
- Context awareness
- Social Interaction Design
- Simplicity

New requirements to allow fast adaptation to users’ daily life needs

**Required Network Operation**

* Higher traffic capacity and performance
* Higher energy efficiency
* Scalability
* Personalized networking services
* Support for a high number of mobile heterogeneous devices (e.g. IoT)
Network Services
Wide Perspective

Note: Indoor cells not shown!
Potential Use-cases
Personalized Network Experience

Baselines
* Operators collect data about the network and users’ behaviour.
* Operators adjust network functions in real-time to adapt different operations to the users’ communication needs (at least priority users)
Potential Use-cases

Edge Networking

Baselines
* Edge data mapping and adaptation for better network resource usage.
* Ensures energy efficient mobility (fine tuned of handover execution).
* Traffic steering among multiple network service classes.
* Self-healing after detection of service degradation.
Baselines

* Distributed Operation
  * Data is kept by the data owner
  * Data is shared based on service agreements
  * No central entity has access to a large set of data
* Data Access Locality to reduce latency of operations:
  * Placing correlated data together.
  * Placing frequently accessed data close to the requester.
* Distribution of computation effort to balance resource utilization:
  * Based on awareness about workload patterns (e.g. data consumption patterns, user mobility patterns).
  * Allocation of computation tasks to balance load across all network nodes.
* Availability:
  * Data can be replicated depending on probability of node failure.
  * Data queries should be aware of nodes energy constraints.
Potential Use-cases
Wireless Networks

Name-based Opportunistic Communication:
- Local decisions about forwarding/routing
- Decentralized name verifications
- Decentralized Trust management

Cooperative Relaying:
- Local selection of best relaying nodes
- Relay switching for higher resilience
- Interference reduction

Multi-cell Wireless Provisioning:
- Every cell is aware of the available resources of other cells in its neighborhood over time.
- Solve interference and frame collision; the exposed terminal problem; the 802.11 anomaly.
Potential Drivers
Cooperation Incentives, Trust Management, Consensus

- Dynamic circles of trust.
- Based on reputation mechanisms.
- Identification of misbehaviors.
- High trust levels lead to more opportunities of cooperation.
- Virtual Identities: Crypto-ID.
- May prevent scalability.

**Cooperation Incentives**

- Avoid scalability issues and the appearance of disjoint groups.
- Cooperation with un-trusted devices.
- Based on a custom virtual currency system.
- Based on cooperation credits which, once earned, can be used to obtain services/resources.
- Penalization of cooperation misconduct.
- Cooperation may increase the reputation of the involved parties.

- Reaching an agreement on a certain quantity of interest that depends on the state of all agents.
  - Ex. optimization of different network functions.
  - Based on classification of time/spatial patterns of data flows.
  - Relies on the self-organization and cooperation.
    - E.g. swarm Intelligence optimization.
    - Investigation needed to allow a completely distributed operation.

**Trust Management**

**Consensus**