Flexible Architecture for the Future Internet

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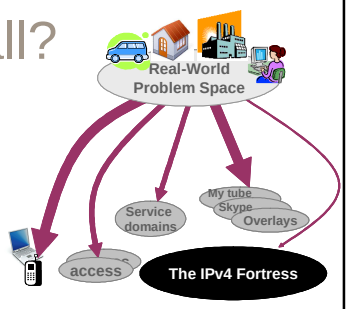
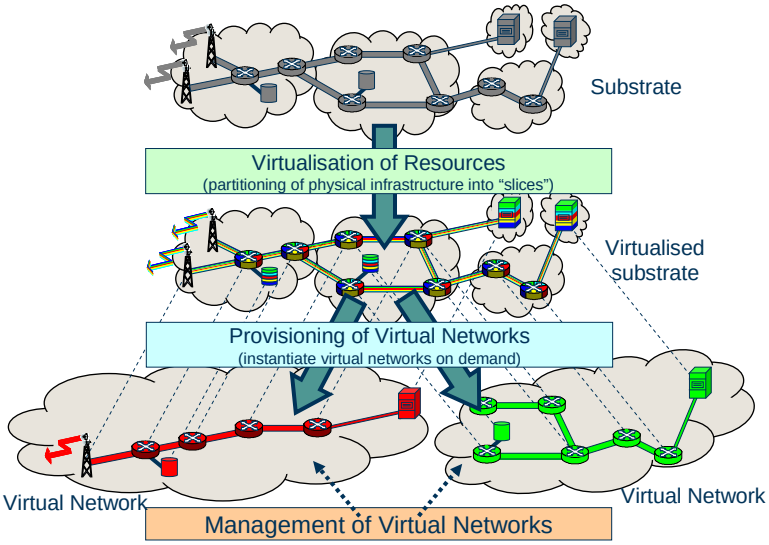
TAKING YOU FORWARD

Has the Internet hit a wall?



- Some of today's challenges:
  - Mobility, identity, address semantics
  - Security (DDOS), private domains
  - Scaling up to massive number of communicating things
  - Operational complexity
  - …
- Innovation is mostly limited to the application layer and the edges
  - Web applications, overlays, access technologies
  - Limited by architectural and engineering constraints of the Internet
  - Ever increasing complexity, low interoperability
- The Internet itself is increasingly resisting innovation
  - "Deployment stalemate" (see [CABO])
  - Incentives/revenue sharing for ISPs vs. net neutrality
  - Slow standardization processes
  - "Patches" (NATs etc.) keep complicating things
- **How can we bring innovation back into the network?**

Network Virtualization Framework



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What can virtualization do for us?

- Deployment and coexistence of innovative new approaches as well as legacy systems in a commercial setting
- Cost-efficiency by sharing infrastructure resources
- Empower service providers to deploy novel E2E services without requiring Internet-wide consensus
  - Overcome "deployment stalemate"
- Flexible resource allocation
  - Set aside resources for high-priority traffic
    - E.g. "Blue Light" applications: Shift physical resources to public safety networks in case of an emergency
- Open up the market for new business roles and competition
  - Trading of infrastructure resources
  - Separation of infrastructure and service providers

Virtualization as the basis for an innovation-friendly, evolvable architecture!
(and not just for experiments!)

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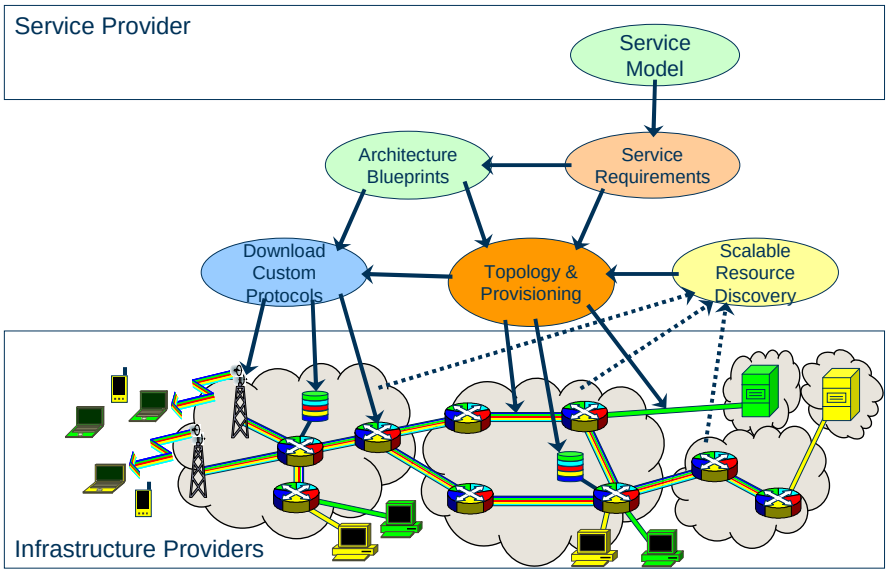
Instantiating Virtual Networks On Demand



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Virtualization Framework

1. **Scalable provisioning of virtual networks**
   - Discover, provision, configure, and aggregate virtual resources on a large scale
     - Resource description
       - Type, capabilities, capacity, connectivity, cost, …
     - Resource trading / bidding
     - Build topology (including mobile and volatile resources)
   - On-demand instantiation of new virtual networks

2. **Virtualization management**
   - Deployment and control of virtual network resources
   - Dynamic reallocation of resources (e.g. for “Blue Light” scenarios)
   - Manage volatile/mobile infrastructure resources

3. **Folding points**
   - Controlled transition between virtual networks
   - Connectivity and interworking
   - Address and data format conversion
   - Protocol translation

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Virtualization of Resources

- Allow customization of programmable resources for maximum flexibility
  - Protocol software download/installation
- Standardized Virtualization Management interfaces
  - Discovery
  - Instantiation of new virtual resources
  - Provisioning
  - Control
- Protection of infrastructure assets via sandbox
- Secure separation of virtual networks

- Fixed resources
  - Routers, switches, links, network storage, …

- Wireless resources (spectrum, wireless infrastructure, mobile nodes)
  - Virtualization of spectrum via
    - FDMA, TDMA, CDMA, spatial separation
  - Virtual basestations
    - Virtualization in the MAC layer
    - Allow co-existing, specialized RLC protocols
  - Mobile nodes as infrastructure resource
    - How to deal with mobile/volatile resources?

Challenges

- Large scale
  - Spanning multiple infrastructure providers
- Fragmentation into isolated network islands
- Performance penalty through virtualization
- Security
  - Network separation
  - Protection of assets and resources
- Signaling in the virtualization framework
- Common virtualization management interfaces
- Accounting, billing, steering of revenue flows
- Manageability, complexity
- Bootstrapping, migration from legacy