



Next hop in routing
Summary of Future Internet WP1 work

Hannu Flinck

Original focus on Routing Scalability

- Motivation: Internet Architecture Board stated (in RFC 4984): **“routing scalability is the most important problem facing the Internet today and must be solved”**
- This resulted into related activities in the IETF and IRTF.
- Our routing scalability work sought answers to following research questions:
 - How would the routing system of the Future Internet servicing several billions of mobile users running real time applications look like?
 - What are the routing objects and related addressing structures?
 - How is the aggregation to be arranged, how are the routes created and propagated,

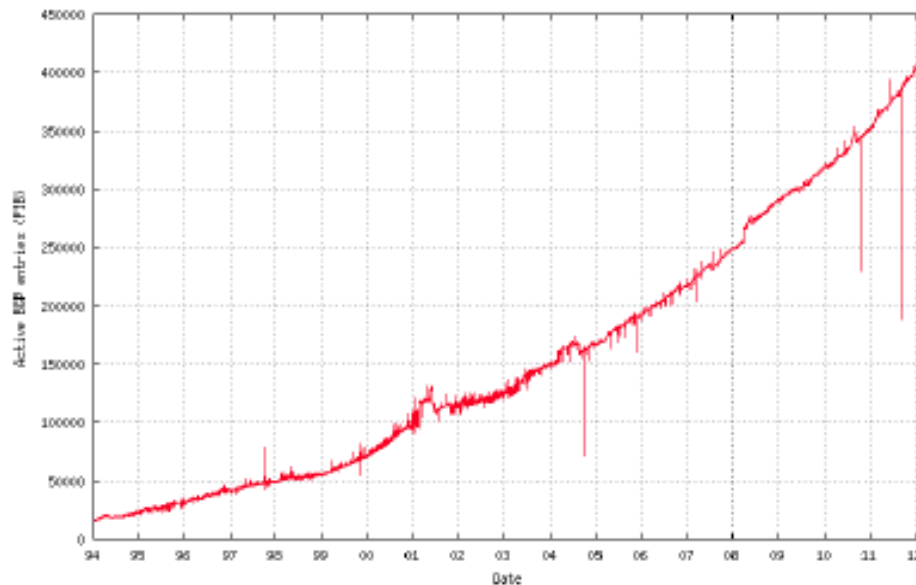


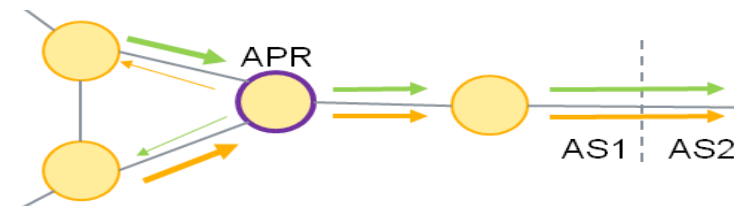
Figure 2.1: Number of prefixes in IPv4 DFZ FIB from 1994 to February 2011. [26]

Root of the routing scalability concern: increasing size of RIB and FIB combined with the number of updates to synchronize the global routing table. Stability of routing system!

Original focus on Routing Scalability (cont.)

- Several routing scalability proposals were developed and analyzed with close relationship to the IETF/IRTF work:
 - Six/One -- a host-based method that supports multi-homing and network-controlled traffic engineering in a scalable fashion
 - Six/One Router -- a router-based method that enables multi-homing, network-controlled traffic engineering, and provider-independent edge network addressing
 - Name based sockets -- a fundamental, yet backwards-compatible re-design of the existing host stack architecture.
 - Renumbering (RFC 5887)
 - Compact routing based mapping system for locator identifier separation
 - Improvements and analysis of Virtual Aggregation

Also worked on related topics:



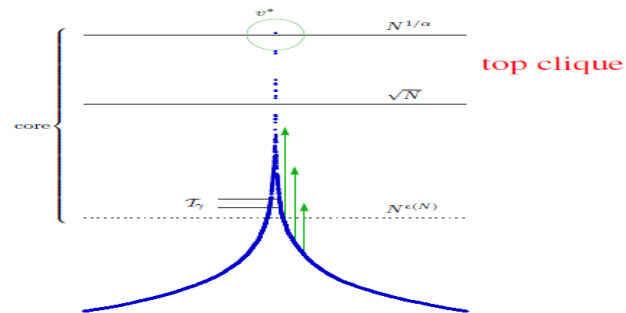
- Home Agent Assisted Route Optimization (HAARO, RFC 6521) => Multi-access work
- Multi-homed HIP, HIP version 2
- IPv6 transition schemes and tools for IETF and 3GPP

Original focus on Routing Scalability (cont.)

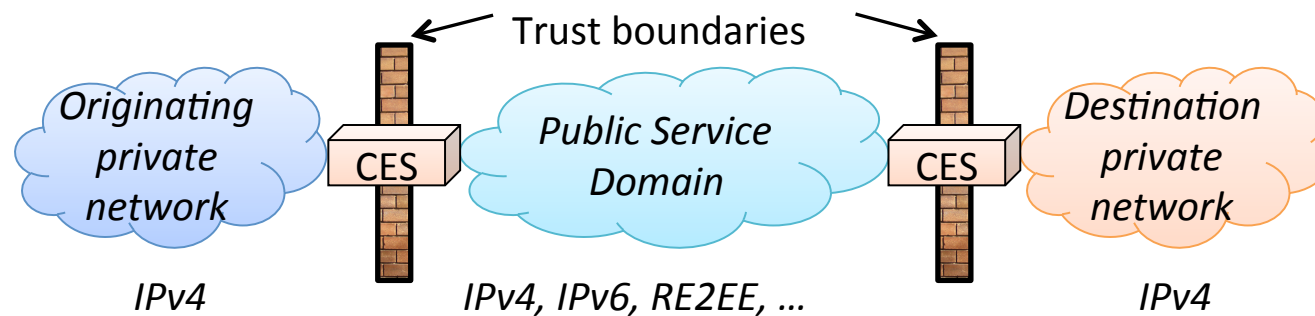
Long term activities beyond IETF:

- New innovative routing schemes based on Compact Routing schemes (powernet)

Ilkka Norros (VTT) @ NGI 2009, Aveiro, July 1–3, 2009



- L2 Customer Edge Switching

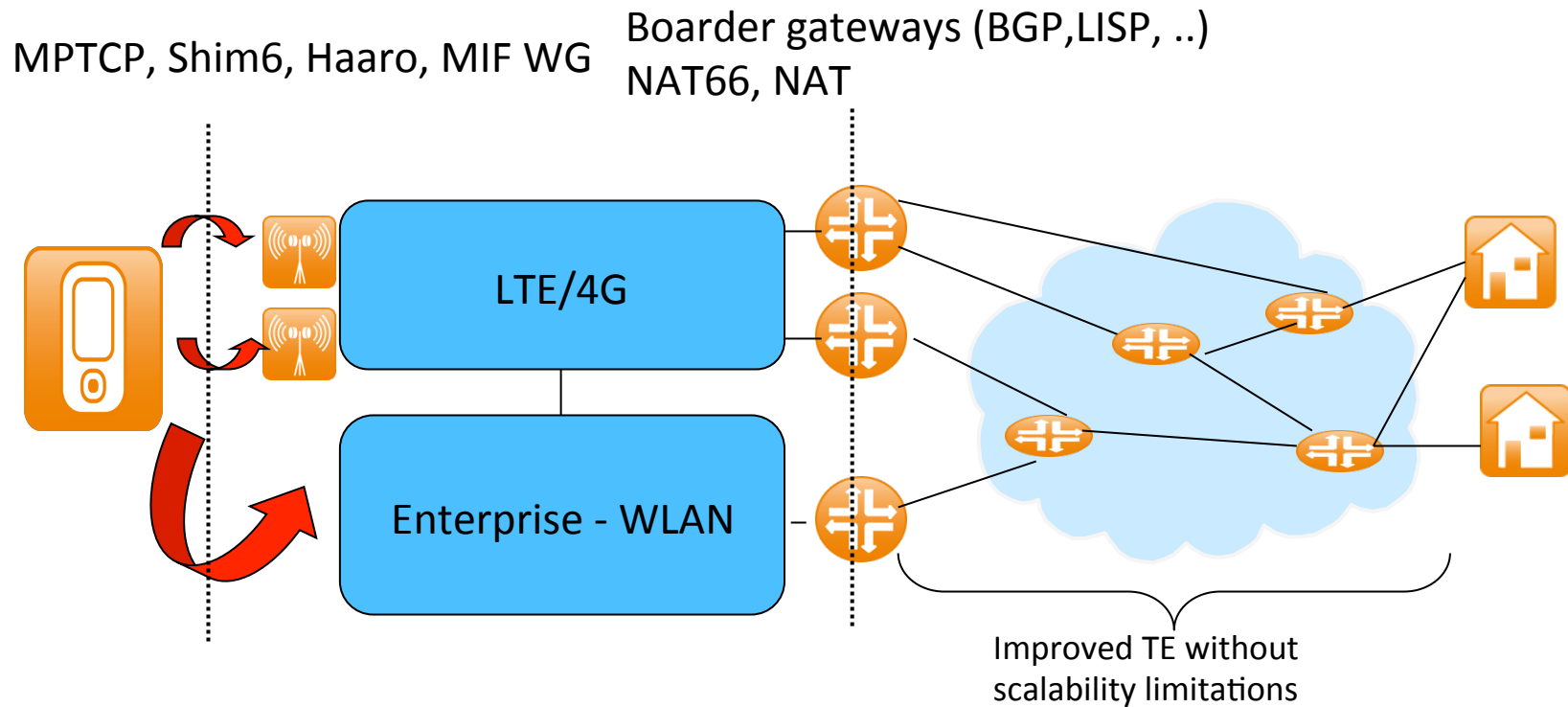


Impact of routing scalability studies

- Routing scalability work in the IRTF concluded into “Recommendations for a Routing Architecture” (RFC 6115)
- WP1 contributed into this work substantially (with four proposals that are referred in RFC6115)
- The IRTF conclusion of routing scalability:
 - Evolution based approaches (FIB/RIB compression)
 - Identifier – Locator Network Protocol
 - Renumbering
- IPv6 transition work resulted into:
 - Guidelines for Using IPv6 Transition Mechanisms during IPv6 Deployment, RFC 6180
 - IPv6 in 3GPP Evolved Packet System: draft-korhonen-v6ops-3gpp-eps



Change of focus from routing scalability to multi-access and multi-path environment



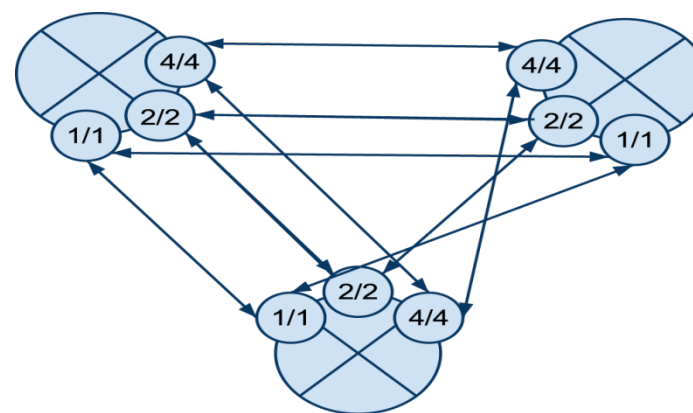
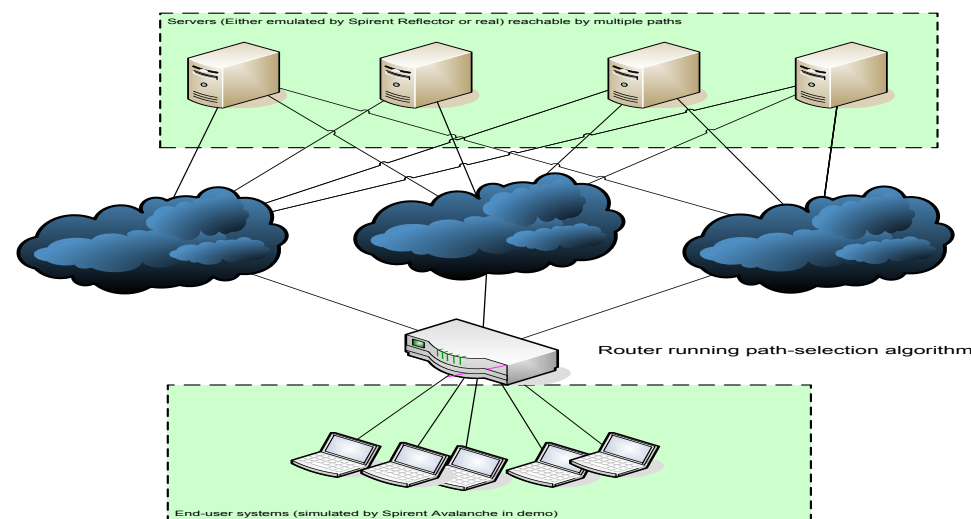
- Multi-access capable terminals (WLAN, xG, etc)
- Site-multihoming
- Path diversity (i.e. multiple alternative paths) with a network

Research questions of multi-access and multi-pathing

TiViT

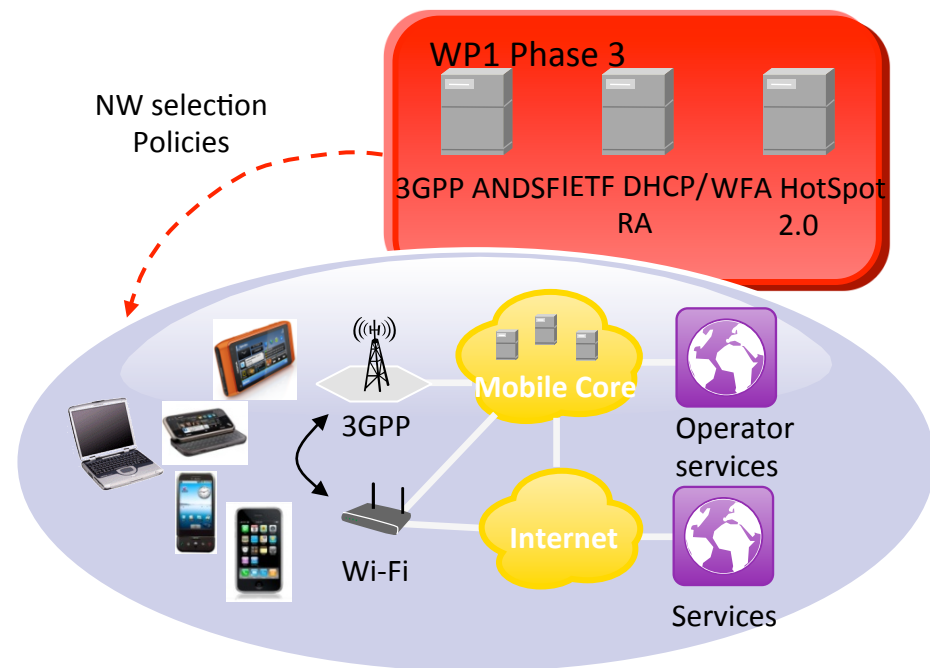
FUTURE INTERNET

- What are the performance impacts multi-access and multi-path?
- How to select accesses and upstream ISPs from alternatives?
- How to create paths across the network? Which paths to use?
- How would multi-path impact real time communications? E.g. how would multi-RTP look like?
- How would multi-path support impact routing protocols and their algorithms?
- What are the business model impacts?
- Research approach: show case driven



Multi-access show case: Utilization of Wi-Fi with cellular networks

- Wi-Fi offload has attracted high interest from the operators as a mean to extend the overall network capacity to manage with the mobile data traffic explosion
- Developed and implemented novel access selection steering mechanisms, which enable cellular operator to loadbalance between 3GPP and Wi-Fi access network usage.
- Improves Quality of Experience especially in-doors where 60 – 70% of traffic is consumed.
- Enables multiple high bit rate sessions with easy of use to a single terminal.
- Operator benefits: less congestion, higher ARPU, re-use of existing infrastructure .
- Business potential: Network vendors need to provide this kind of solutions to have future network-deals.



ANDSF= Access Network Discovery and Selection Function

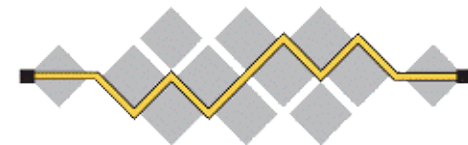
High-performance SW directed packet routing



- Performance evaluation of software switching using commodity hardware
 - Hardware-accelerated Click using Octeon
 - The results promise that these platforms are good for rapid testing of new protocols and adding new functions for network operation.
 - The borderline between testing environment and commercial product will be diminished because the same platform can be used in both phases.
 - **A toolchain that compiles a Click software router to a hardware design loadable into a NetFPGA card.**
 - Demonstrates that it is possible to compile existing software router to hardware.
 - Allows for faster prototyping of hardware routers in future research and these techniques may also be used to fasten product development
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Conclusions

- New routing architectures will be based on locator – identifier separation, but evolution of the traditional routing will still meet the current needs
- Multi-access and multi-path improves performance and reliability. Business model impact requires more elaboration
- SW routers are matching low end HW routers. They enable rapid development and commercial deployment of new protocols
- Many contributions to standardization:
 - Recommendations for a Routing Architecture
 - LISP, renum, v6ops
 - Multi-homing and Multi-path support: RTP, HIP, HAARO
 - IPv6 migration guidelines to 3GPP as well as to IETF



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