

Research and Development Advances in Routing for “Future Internet”

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Topics

- What is the Future?
- What is Driving These Discussions?
- Fertile Areas for Work
- Learning Lessons from the Past
- How to Introduce New Work in the IETF
- Where to Discuss Architecture in the IETF Context
- Research and the Internet

The Future is Bright – But What is it?

- Lots of pizzazz and hype around 5G and the new services
- But, this is not really about 5G, it's about new services on the Internet
 - 5G just makes them more broadly available
- New services will always come along
 - Beware of using them as justification for technology
 - Look for the real services and applications
- What applications?
 - Remote surgery
 - Haptic interactions
 - Holographic conferencing
 - Multi-player VR or AR gaming
 - Vehicle automation
 - Manufacturing
 - Crowd-sourced video
 - Digital trading

The Driver

New Services Need New Network Behaviours

- Most of the new applications demand some improvement in networking
 - Greater bandwidth (throughput)
 - Lower delay (less latency)
 - Less variation in delivery time (reduced jitter)
 - More independence (less impacted by other traffic)
 - Better reliability (less packet loss / corruption)
 - Better resiliency (less affected by network failures)
 - Better security (faster, more private, more secure)
 - Better manageability (automated, flexible, responsive)
- This is not a new list!

Bigger Faster
Stronger Better

Where (in the stack) Could We Work?



- All layers of the stack are candidates for improved network performance
 - May be better to think in terms of IETF Areas
 - Application and Realtime Area
 - Codecs, enhanced RTP usage, improved encodings
 - Transport Area
 - Picking paths, multiplexing, improving throughput
 - Internet Area
 - New or enhanced encapsulations to carry flow-specific information, timing, IP-over-foo, compression
 - Routing Area
 - Picking routes with different qualities, directing traffic according to network variation, routing in specific environments
 - Operations and Management Area
 - Autonomics, telemetry, SDN, device identification
 - Security Area
 - Better, faster, stronger

What Do We Know Already?

- Introducing new technology is hard
 - Backward compatibility with deployed equipment/software
 - Need to upgrade whole networks
 - Often needs a big commercial or regulatory incentive
- Many new ideas fail
 - A lot of time and money can be invested in things that never take off
- Innovation requires open doors
 - Let a thousand flowers bloom
 - Sometimes good ideas have unlikely origins
- The future is hard to predict
 - New applications and new technologies
- Evolution or Revolution?
 - Evolution may be much easier to achieve



Bringing New Work to the IETF



- Develop some collaborators with similar interest
 - Not just names, but people who want to do the work
 - Multi-vendor support
- Write some initial Internet-Drafts
- Maybe have some Bar BoFs or side meetings
- Talk to Area Directors in the relevant area
 - This is usually missing or late
- Propose a BoF (drafts, charter, agenda all needed)
 - “Most successful requests are due to good proponent preparation” – Alvaro Retana RTG AD
 - Getting early input from IESG and IAB is essential
- Hold the BoF (Consensus determines the next steps)
 - Identify meaningful work to be done in the IETF
 - Protocol work
- Charter bashing
 - Most edits are about clarity and scope
- Working Group formed
- Check out ... Tutorial on Bringing New Work to the IETF:
 - slides: <https://datatracker.ietf.org/doc/slides-103-edu-sessl-bringing-new-work-to-the-ietf/>
 - video: <https://www.youtube.com/watch?v=YnK3rsZG4Ec>

Some Experience of Recent Routing Innovation

	RIFT	BABEL	Segment Routing	PCE	SFC
Problem space	Data centre routing : limited domain	Specialist networks	WAN and backbone networks	Specific domains and backbone networks	Specific domains and provider networks
Early support	Single vendor	University research	Single vendor with some university support	Single vendor with support of several operators	Multi-vendor and operator interest
Running code	Public “open source”	Open source	Private proof of concept	Private proof of concept	None
Ease of deployment	Software upgrade to all routers in a domain	Software upgrade to all routers in a domain	Software upgrade to key routers. Firmware upgrade in some cases.	Software upgrade to key routers. Addition of a server	Deployed as an overlay
Introduction to IETF	BoF describing whole problem space and discussing working code. WG formed for RIFT.	Published through Independent Stream as experimental. WG formed to enhance protocols.	BoF held with some description of protocol solutions and 10 drafts posted.	Two BoFs needed to define problem space. Work on requirements and architecture before solution protocols.	Mailing list established. BoF held after 21 drafts posted.



Internet Architecture and the IETF

- The IETF's mission statement is:
 - *“to make the Internet work better by producing high quality, relevant technical documents that influence the way people design, use, and manage the Internet”*
 - That should include planning the future architecture of the Internet
 - But principally, the IETF engages in solving immediate engineering problems
 - 1 to 5 year horizon
 - Standardisation for deployment
- The IAB:
 - *“provides long-range technical direction for Internet development”*
 - That makes it the forum for longer-term, strategic work
 - The IAB maintains a mailing list *“for all long and/or wide range architectural concerns related to the Internet Architecture”*
 - *“In particular, it may be used to discuss and bring forth different points of view on controversial architectural questions”*
 - architecture-discuss@ietf.org
 - The IAB may set up a “Program” or hold a “Workshop” to study a particular point
- Internet-Drafts remain the best way to state a position for wider discussion

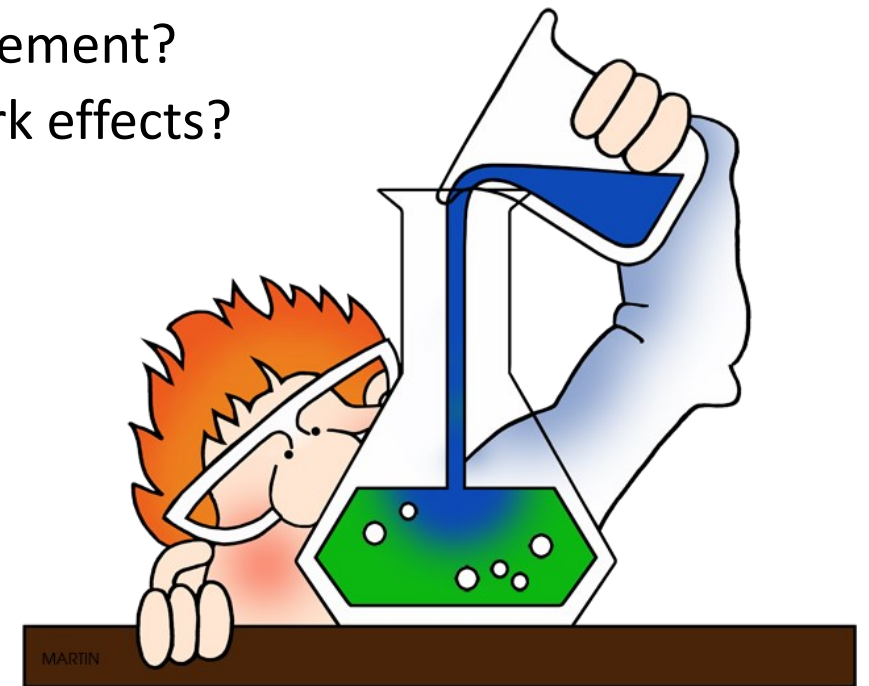
Research and the Internet



- The Internet Research Task Force (IRTF)
 - *“promotes research of importance to the evolution of the Internet protocols, applications, architecture and technology”*
- Key words *“promotes research”* not *“does research”*
 - “promote the development of research collaboration and teamwork in exploring research issues”
- It’s a place to bring your research for discussion and coordination
- Research Groups provide focus
 - A new RG might be set up if there is evidence of an emerging research area
 - In other words, if people are actively engaged in research work outside the IRTF

What Research?

- What applications and services do we **really** need to support?
 - There is a difference between dreams and immediacy
- How can we enhance network performance to meet the requirements of new applications?
 - Packet marking and metadata
 - Modifications to routing protocols
- What can we achieve by enhancing tunnelling and transport protocols?
 - What have we learnt from RTP, QUIC, and MPTCP?
- What could we do through better operations and management?
- How should we design our applications to handle network effects?
 - Don't we already do this?
- What form does research take?
 - Experimental protocols and implementations
 - Quantitative measurements of network behaviour
- Where can we do our research?
 - Universities and corporate research labs
 - Publish in journals and at the IRTF



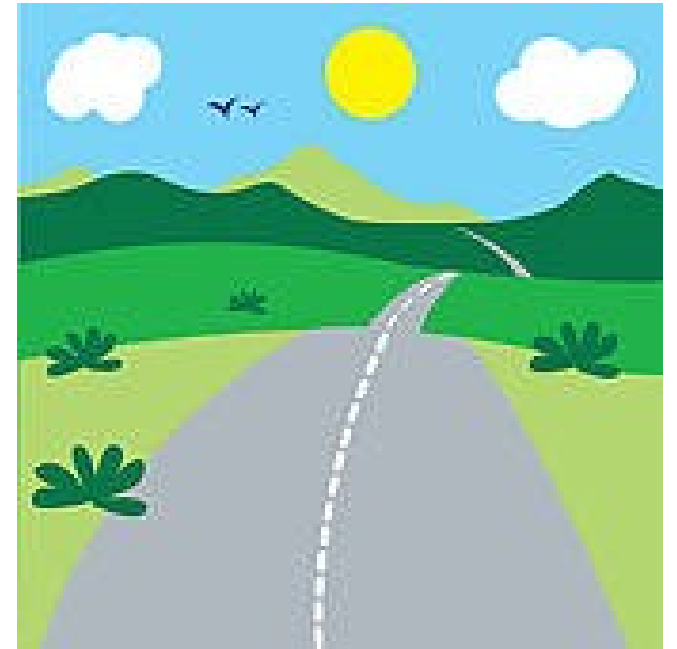
Outlook for Internet Routing

- Improved security for routing protocols
 - Continues to be a neglected aspect of Internet routing
 - Particularly interesting for inter-domain routing
 - Research in MANRS
- Telemetry and diagnostics
 - Specific to the operation of the routing subsystem
 - Various IETF projects, but no overall architecture
- Provision of routes for specific service qualities
 - Measurement of behaviour of network nodes and links
 - Specification by applications of service requirements
 - Marking of packets according to service requirements
 - Routing of marked packets onto path that best deliver service requirements
 - IETF Network Slicing and Application-aware Networking (APN)
- Routing for specialised environments
 - Closed networks have specialised needs
 - Data centres
 - Satellite networks
 - Inter-planetary networking
 - IoT networks (factories, streets, homes, ...)
 - A lot of IETF projects (BABEL, ROLL, DetNet, DTN, RIFT,)
 - Lots more potential

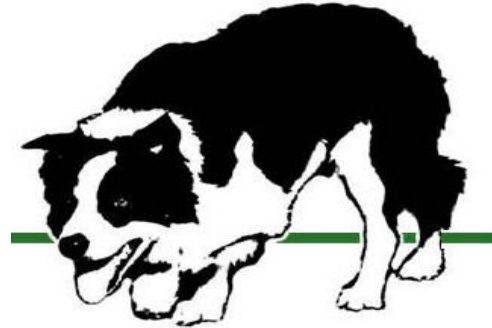


Far Distance for Internet Routing

- Continued examination of addressing schemes
 - Hierarchical addressing
 - Functional decomposition
 - Part of an address has a non-routing meaning
 - Identifies a function or content (see also, Segment Routing)
 - Geographic decomposition
 - Addresses are structured like NSAPs or telephone numbers
 - Research target
 - Impact on legacy addressing and routing schemes
 - Implications for global routing, privacy, and geopolitics
- Service routing and semantic routing
 - Avoid DNS latency using a Service ID hashed from target domain/service name
 - Route based on Service ID with updates to routing protocols
 - Research target
 - How does this scale?
 - Can it be applied to specific scenarios?
 - Private networks (local or worldwide)
 - Multi-access edge computing (MEC)
 - Overlay networks (tunnels between Service routers)



Questions and Follow-up



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