Measurement, Monitoring and Control of Internet Traffic for Improved QoS

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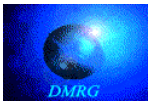

Agilent Technologies
Innovating the HP Way

On the Applicability of In-line Measurements for Next Generation Networks

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Motivation & Challenges

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- Reveal the properties of the service experienced by network traffic
- Surpass the limited functionality of passive network monitoring, by providing service measurements
- Avoid measuring the properties of synthetic traffic, rather instrument the existing traffic
- Exploit systems and network programmability

Measuring, Monitoring and Control (MMC)

- Network Management traditionally device-centric
  - SNMP was the de-facto standard
  - Typically used to ensure optimal operation of the devices within a network cloud
- MMC: A form of Network Management and Operations
  - Less device-centric more service oriented
  - Mostly concerned with traffic flows and end-to-end paths' properties
  - Can be a way of providing for differentiated services and SLA policing

Current Measurement Activities

- Measurement instrumentation in current best-effort networks
  - Mostly have a diagnostic role of the status of the network behaviour
  - Can also serve as a long-term planning factor for network administrators
- Two main categories: Active and Passive techniques
  - Active: generate new traffic; perform measurements on it
  - Passive: existing network traffic is recorded & analysed

Active Measurement Architectures

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- Mainly focused on characterising link/available *bandwidth*, *packet losses* and *latency*, based on standards work within the IETF IPPM WG
- Inject special-purpose traffic with known characteristics, at pre-defined time intervals; ICMP, UDP packets mainly used
- Suitable for two-point and end-to-end measurements
- Example projects: PingER, Surveyor, RIPE NCC TTM, NLANR AMP

Passive Measurement & Monitoring Tools

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- Monitor the use of the links based on the existing traffic, from routers' management software
- Data collection and analysis based on pattern matching techniques to filter traffic of interest and search for particular events
- Highly accurate techniques, suitable for one-point measurements.
- Example tools: SNMP, RMON probes, NetFlow, MRTG

Limitations and Inaccuracies

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- Active Measurements
  - Misleading measurements produced, due to the use of special-purpose traffic
  - Periodic sampling may not observe network events occurring at other times
  - Extra network load produced by the special-purpose traffic
- Passive Measurements
  - The pull/push models used may end up shipping large amounts of measurement data
  - Long standardisation processes
  - Difficult to correlate samples collected at two distinct points

In-line Measurements – A New Era?

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- An effort to design a hybrid approach, combining the positive aspects of both active & passive approaches
- Triggers invoking the measurement activity, and the measurement data itself are piggybacked onto real traffic

- Exploit network programmability:
  - Exploit IPv6 Extensibility mechanisms
- Exploit systems programmability:
  - Design an open, extendable and lightweight measurement framework

IPv6 – A New Programmable Framework

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- Extendable Protocol Specification
  - Facilitates the introduction of measurement & management extensions within the protocol itself
  - Provides for additions and incremental deployment
- IPv6 Extension Headers
  - Mechanism that provides for processing of additional functions (other than the main IP forwarding)
  - Headers can encode options in a Type-Length-Value format (TLV)
  - Ignored at nodes, if not supported
- Design a special, measurement header
  - Trigger measurement activity at the appropriate nodes

Advantages of IPv6-based, In-line Measurements

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- Embedding measurement functionality into IP can facilitate end-to-end Internet applicability & compatibility
- Piggybacking measurement data onto real user traffic:
  - Can virtually guarantee that results will reflect the actual service experienced
  - Can reduce the amount of measurement data carried across the network
  - Can keep the overall overhead incurred at an estimated and anticipated minimum

Protocol Engineering

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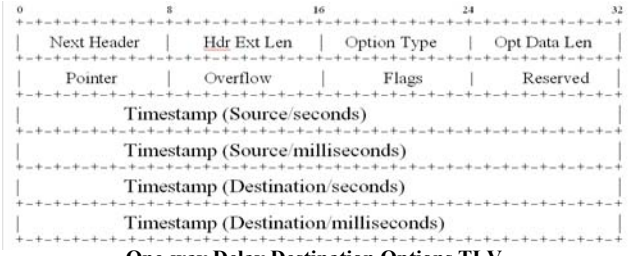
- Define a dedicated header without altering packets' forwarding behaviour
  - A destination options header, experimentally measuring one-way delay
  - Keep real-time processing at a minimum and analyse results off-line



One-way Delay Destination Options TLV

Systems Implementation

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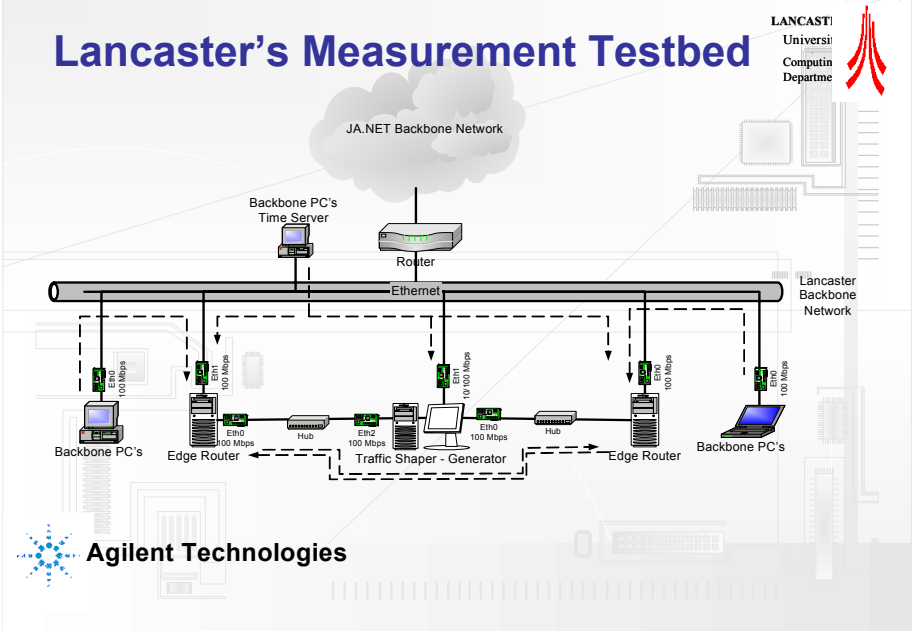
- Build the measurement functionality as dynamically linkable Linux kernel modules
- When loaded, the modules examine the headers of the IPv6 packets passing through the network interfaces
  - At ingress: create the extension header and add a timestamp of packet arrival
  - At egress: add a timestamp indicating packet arrival time and then copy the entire IPv6 and transport headers into a queue structure for off-line processing
- Data is passed between the kernel and user space through a virtual device and IOCTL calls

Lancaster's Measurement Testbed



Testbed Setup

- Emulate an access network
- Instrument systems acting as edge routers
  - Packets are being tagged at ingress and egress points
  - Introduce delays and additional load in the network
- Experiment with different scenarios for invoking measurements
  - Sampling, on-demand, etc.
  - Measure on top of characteristic applications (e.g. video streaming, Web-TCP, etc.)
- Move instrumentation to the end-systems?
  - Try to measure end-to-end path properties

Conclusion and Further Work

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- Perform scheduled or on-demand measurements onto real user traffic, revealing the properties of the experienced by the various services
- Experiment with different Extension header formats, measuring several network properties

- Keep the associated overhead at an absolute minimum
  - Evaluate the corresponding systems and network overhead
- Move one step forward: from diagnostic to operational measurements?

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