A Precision Infrastructure for Active Probing

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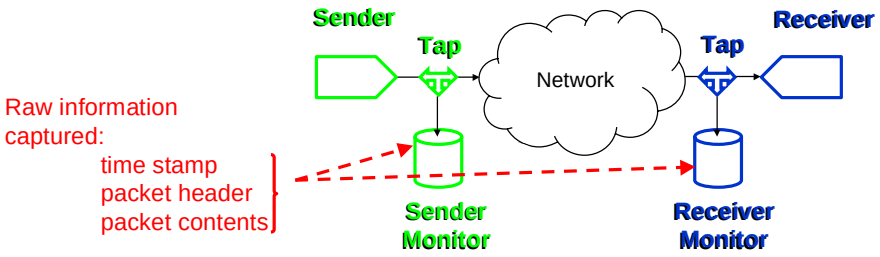
Introduction

1. **Active Measurement**
2. **Timing Control**
3. **A Precision Infrastructure for Active Probing**
4. **Early Experiments**

Active Measurement

Active measurement is the injection of artificial probe traffic and the measurement of its characteristics.

- \- invasive character
- \+ end to end nature
  - flexibility in probe stream design
  - measurement data volume reduction
  - avoidance of data privacy issues



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Timing Control

- **Terminology**
  - resolution
  - offset $\Theta(t)$
  - skew γ
  - stability ~ $\omega(t)$

$$\Theta(t) = \gamma \, . \, t + \omega(t)$$

- **PC clocks**
  - SW clock - based on a periodic interrupt, triggered by a timer chip
  - using processor TSC register - µs resolution
  - typical skew 50 PPM, typical stability 0.1 PPM
- **Clock synchronisation**
  - NTP
  - GPS or other reliable reference clock source
- **Scheduling**
  - executing tasks on the desired time

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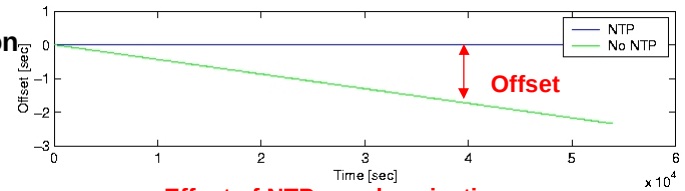
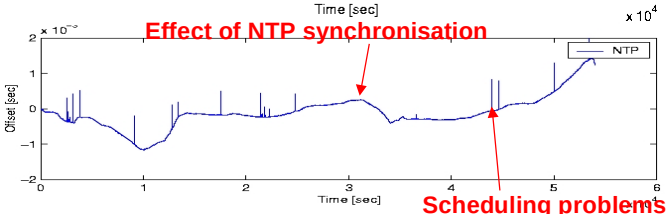
Timing Control

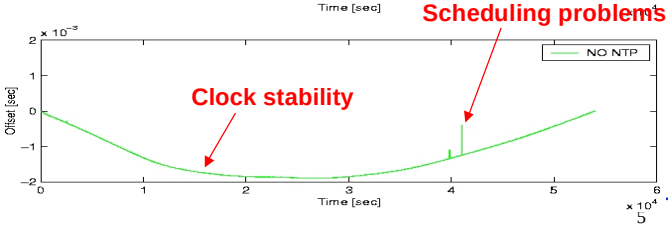
- Offset Comparison



- NTP close-up



- NO-NTP corrected for the skew



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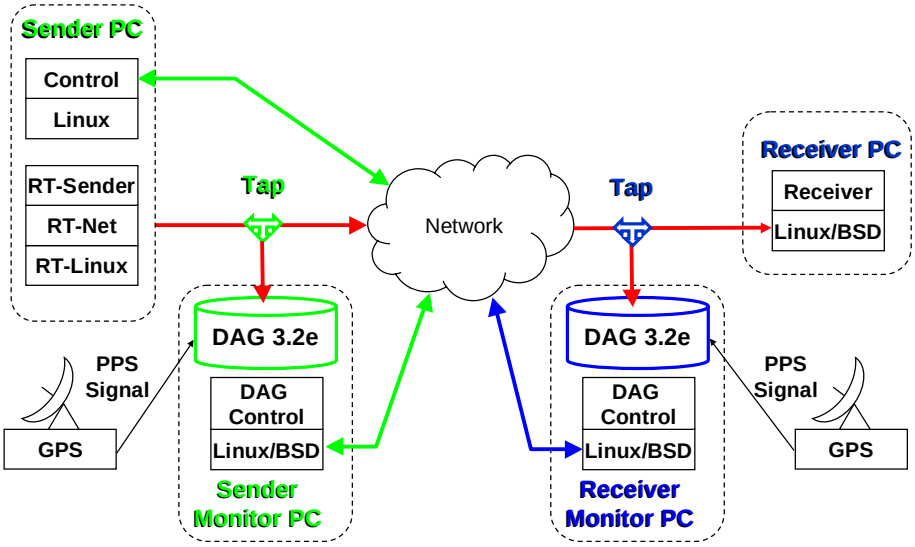
A Precision Infrastructure for Active Probing



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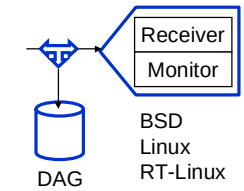
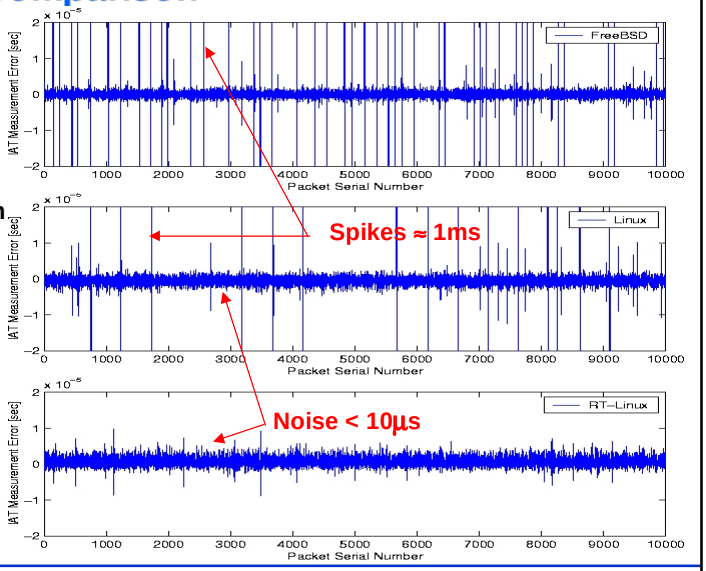
Monitoring Comparison

- **DAG used as a reference**
- **The measured packet inter-arrival time is compared**
- **Pseudo Poisson stream of 10000 UDP packets with mean inter-arrival time of 10ms**



DAG
Ref.monitor

BSD
Linux
RT-Linux



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The Senders

- **The Sender defines and injects the active probe stream into the network**
  - the probe stream is defined by
    - **packet type (UDP,ICMP,..)**
    - **packet contents**
    - **sending process - pattern of inter-departure times and packet sizes**
- **Scheduling algorithms**
  - Active - unnecessary CPU load, resulting in scheduling problems
  - Passive - using `usleep` and `ualarm`, resolution problems
  - Hybrid - low CPU load, high resolution
- **The current version of the Sender**
  - is using hybrid scheduling
  - is implemented under BSD, Linux and RT-Linux
  - sends UDP packets with a serial number as payload

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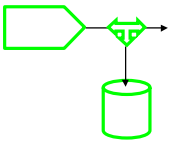
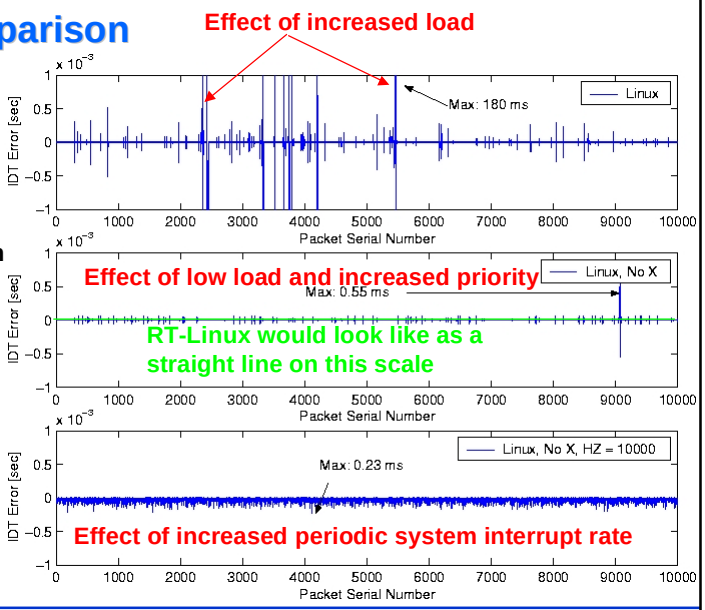
Sender Comparison

- DAG used as a monitor
- The target and measured packet inter-departure time is compared
- Pseudo Poisson stream of 10000 UDP packets with mean inter-arrival time of 10ms

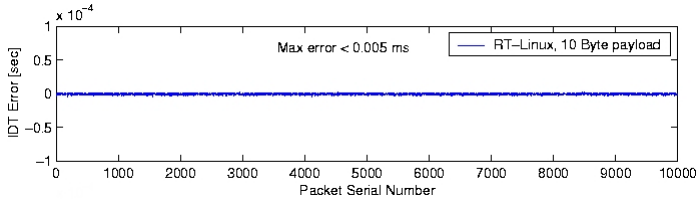


DAG Monitor



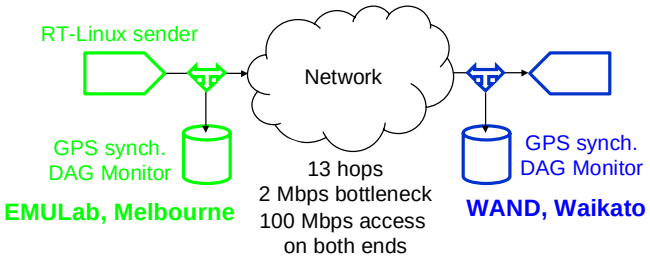
Sender Comparison

- RT-Linux



Early experiments

- **Configuration**



- **Experiment I.**
  - Sending short periodic streams of *small* and *large* packets with rates well below, app. around and well above the bottleneck rate
- **Experiment II.**
  - Comparison of a periodic and a simple designer probe stream

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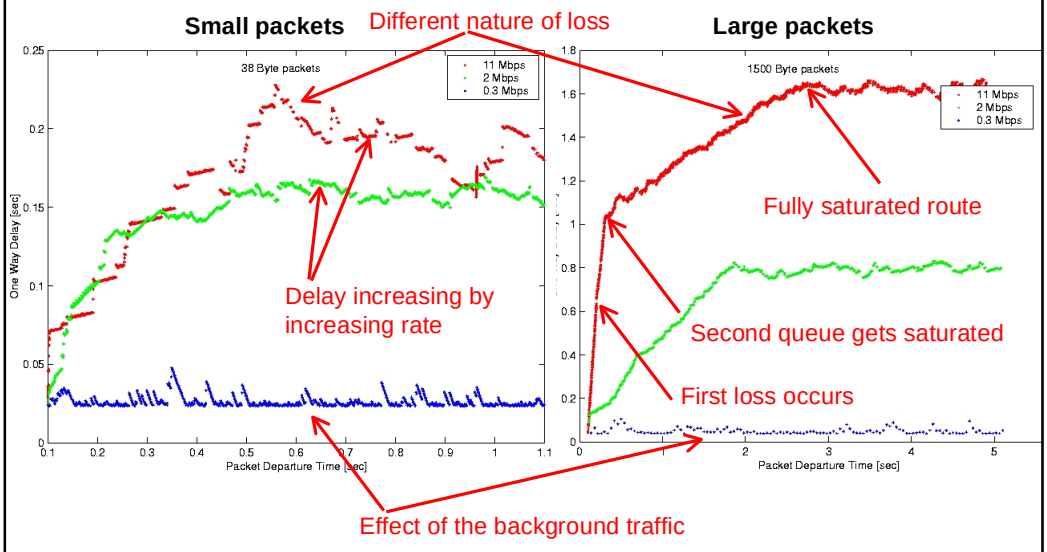
Experiment I.



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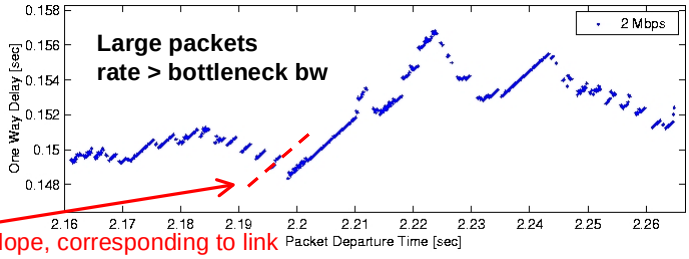
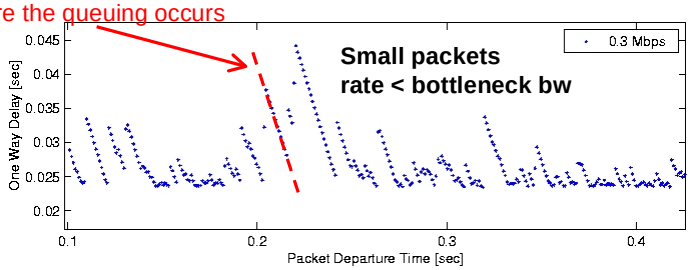
Experiment I.



Characteristic slope, corresponding to link bandwidth where the queuing occurs



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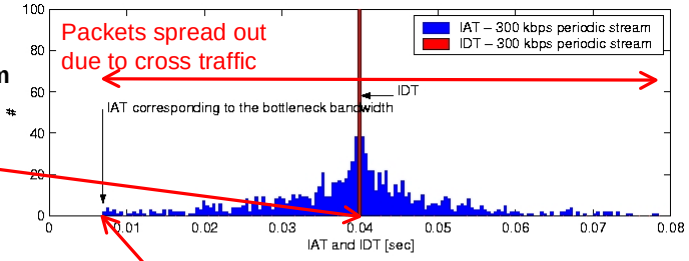
Experiment II.

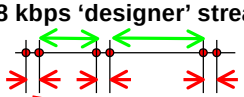
300 kbps periodic stream

IDT corresponding to the period

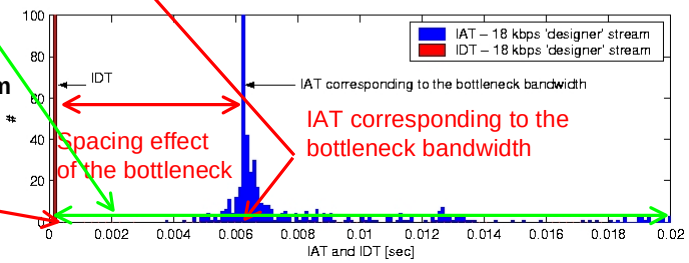


Poisson distributed inter pair IDT spread out

18 kbps 'designer' stream



IDT corresponding to the intra pair period



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Conclusions

- **A highly accurate active probing infrastructure was developed**
  - reliable monitoring
  - reliable transmission of high resolution probe streams
  - accuracy << 1ms
- **Comparison of different Unix on PC solutions**
  - RT-Linux clearly superior, scheduling errors ≈ 10µs
  - BSD and Linux - errors in the range of 1ms
- **Network based clock synchronization**
  - produces undesirable effects in the sub-millisecond range - NOT RECOMMENDED
- **Preliminary experiments**
  - system accuracy demonstrated
  - high resolution histograms - leading to new means of measuring link rates

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