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FNSNF

Defining the Operating Region of the ADN Communication Network

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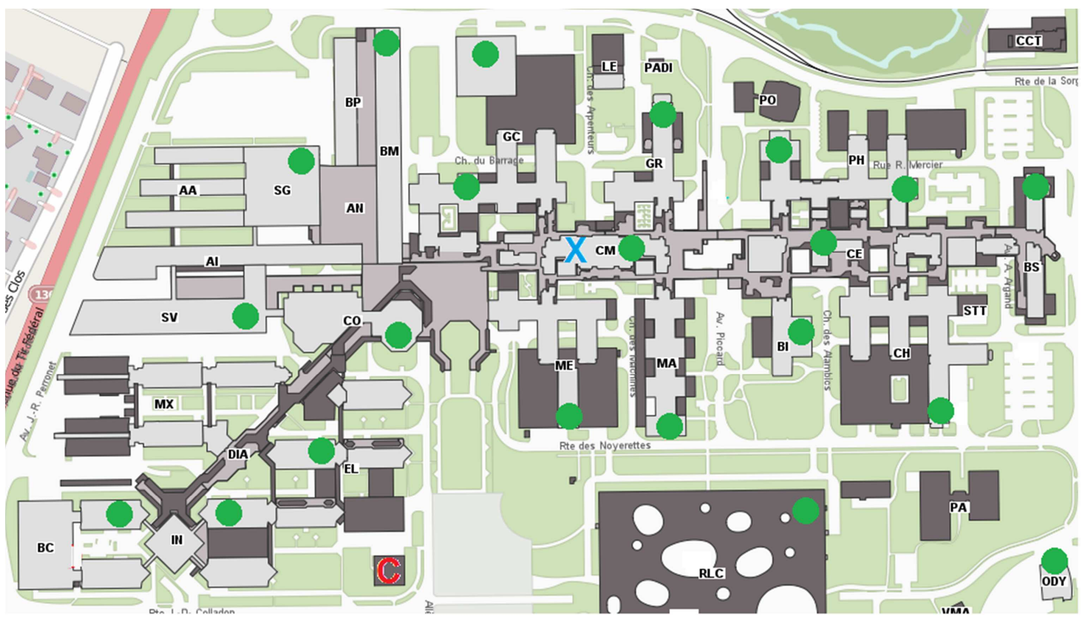
On –campus Active Distribution Network

* Phasor Measurement Units (PMUs) stream measurement data (voltages, currents) from the medium voltage transformers to the State Estimator.
* State Estimator makes decisions based on the received data. Those might be control and/or protection decisions.
* Reliability and timing requirements are critical: we want to close the loop within 20ms without excessive packet losses.



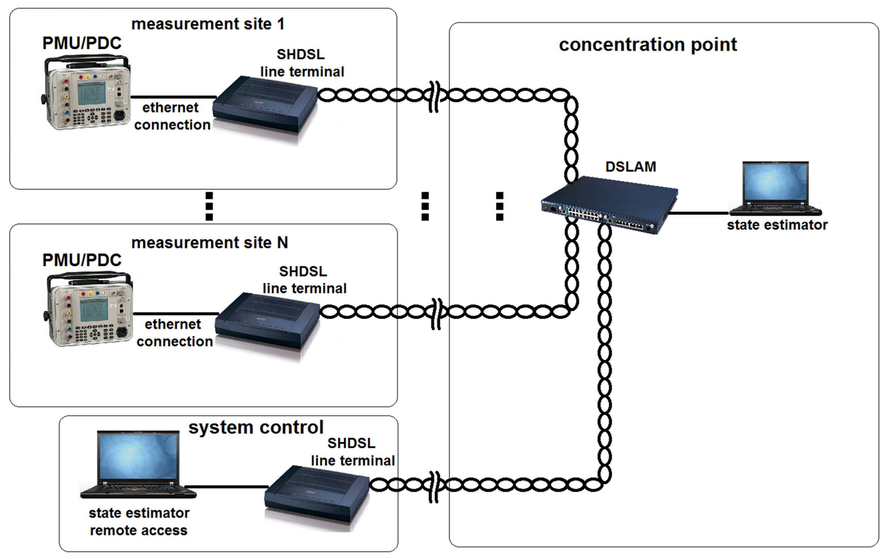
C System control

X Concentration point for the wired solution

Measurement sites equiped with PMUs (medium-voltage substations)

Dedicated Communication Infrastructure

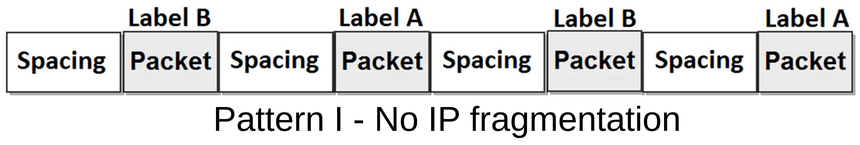
- We use SHDSL technology over passive twisted pair cables.



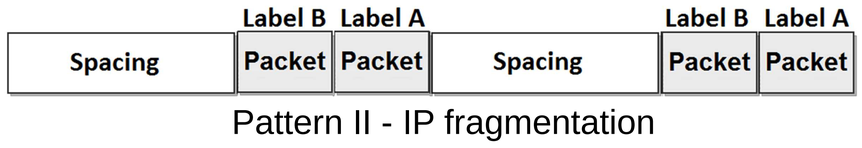
* The goal of this performance evaluation [1] is to define the operating region of the wired infrastructure (maximum throughput, RTTs, system behavior when the offered traffic is above the channel capacity) before deploying the equipment.

Experiments

* We send 10000 Label A packets and 10000 label B packets.
* We observe the number of successfully received packets (IP layer) and the number of successfully decoded bytes at the transport layer (UDP payload).

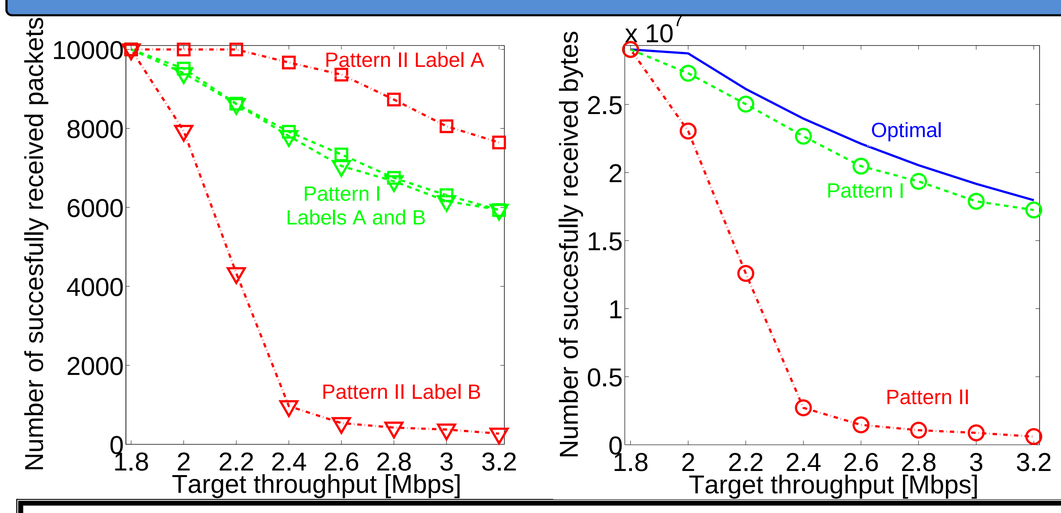


Pattern I - No IP fragmentation



Pattern II - IP fragmentation

Results

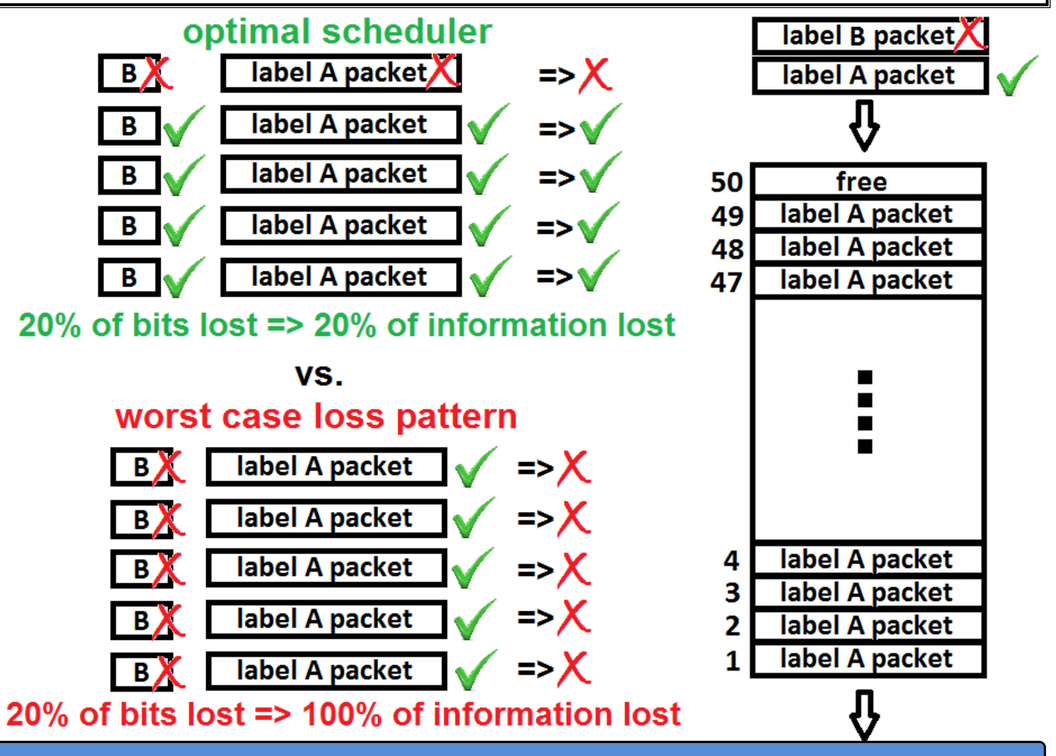


* Label A packets size: 1452 B, Label B packet size 363 B, 10000 packets of each kind are sent. On the left: number of successfully received packets. On the right: number of successfully received bytes as seen by transport layer.
* When the offered traffic is slightly above the capacity (~10%) we identify scenarios where packet loss probability is much higher (~57%), i.e. above the optimal expressed with

$$\text{loss probability} = \frac{\text{offered traffic} - \text{line capacity}}{\text{offered traffic}}$$

Explanation – Unfortunate Loss Pattern

* Small buffers with tail-drop policies are discriminating Label B packets which leads to high loss of information (example on the left).
* These findings are confirmed by simulations (typical situation at the queue on the right).



Take-home Messages and Solutions

* Traffic management mechanism are necessary to ensure sufficient networking resources (currently out of scope of IEEE C37.118.2 standard for synchrophasor data transfer layer).
* Quick fix – datagram-aware schedulers for the bottleneck queues.
* Systematic approach – traffic shaping (e.g. Integrated service architecture) implemented on machines that run real-time OS.

Bibliography

[1] M. Popovic, P. Gao, D.-C. Tomozei and J.-Y. Le Boudec. *On the Necessity of Traffic Shaping for PMU Measurement Data Streams*. Power and Energy Automation Conference, Spokane, Washington, USA, 2013.