# Design context

There are two major strategies to analyze the network impairment of streaming data. The more common strategy involves the use of purpose built network simulators that are able to process data flows through component level models of network stacks, buffers, switches, routers and links. This approach typically exposes a large set of tunable parameters in order to simulate the network at great detail, the down side of this complexity is that the simulation results are not always easily reproducible between simulation tools. Also, the large number of parameters greatly increases the complexity of Monte Carlo style parametric analyses.

The other approach represents the network as as composition of several stochastic primitives. These primitives are usually derived from empirical analysis. Several of them have been validated extensively for standard network types and take the form of finite order probability distributions or statefull random processes. We use this latter approach in the Network Impairment Module.

# Overview of stochastic approach

Our model uses a Poisson arrival process to model message rate modulation due to network access effects and delays in the data bus. A single data queue couples the Markovian arrival process with an exponential distribution of service times. Service time distribution captures the variation introduced by data aggregators, processors, PDCs, etc. This model format (typically called an M/M/1 queue using the Kendall's notation) is frequently used to model the aggregate performance of web based database services such as SQL server queries.

Finally, we consider a two-state Markov approach as introduced by Gilbert and Elliott to characterize a burst-noise channel. The model adds memory to a binary symmetric channel coded into two states of a Markov chain modeling the performance of error detection and recovery mechanisms in transmission channels. Note that the full network model comprised of its four principal components can be formulated as a continuous time Markov chain with a closed form Pollaczek-Khinchin expression for network delays. Since each model parameter is explicitly represented in the final expression for the full model, our approach enables parametric surveys to be conducted using Monte Carlo methods. We expect that the close form expression for network impairment would yield itself to formal guarantees on the compactness of a hull derived from the Monte Carlo analysis.

# Overview of network impairment module.

The Network Impairment Module receives:

1. m × n clusters from the Measurement Impairment Module. Assuming, ‘m’ PMU instances producing measurements for ‘n’ time instances.
2. n – tuple time index corresponding to the measurements being impaired (Produced by the Event Generator Module).
3. An m × m matrix of doubles constituting the ‘Impairment Parameters’. These parameters are computed a-priori and may represent a variety of probability distributions. In the general case, they are derived for a buffer mediated combination of a Poisson and Exponential distribution.
4. A 2 × m matrix of doubles expressing the packet loss thresholds for the network. The first row of m doubles represents the time limit on the PDC or application measurement buffer for each PMU stream. The second row of doubles is the loss probability for the two step Markov chain used to capture bursty network loss events.

The Network Impairment Module transmits:

1. m × n clusters of measurements with element wise binary coloring ∈ {lost, not lost}.
2. n – tuple time index showing the added delay introduced by the network.



Figure 1: A schematic representation of the network impairment module. Light Blue boxes represent inputs and outputs. Dark Blue boxes represent input control parameters.