Ersatz

A Discrete Event Simulation of Distributed Applications

Brett Viren

Physics Department

BROOKHAVEN NATIONAL LABORATORY

protoDUNE DAQ Sim

8 Jul 2016

CAVEAT AUDITORIUM

This is still very much a work in progress.

Anyone interested in getting involved?
You are very welcome!

$\rightarrow$ for now, still heavy on the concepts,
light on the results....

protoDUNE/SP Data Scenarios

DUNE DocDB 1086-v6

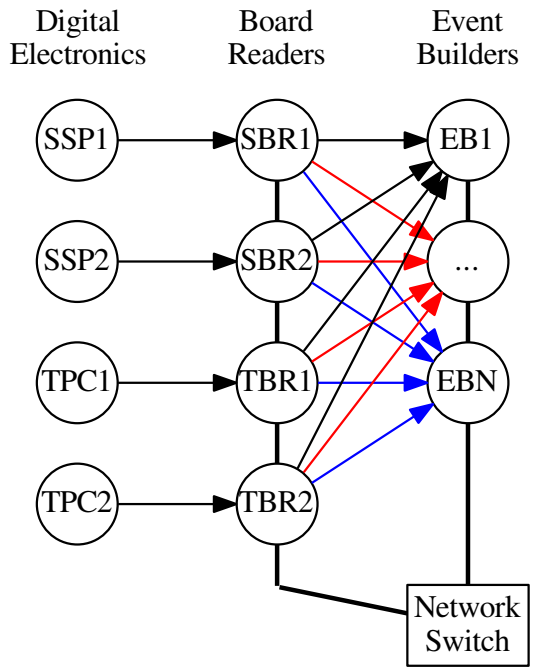
- Capture quantitative assumptions and implications and guide design.
  - (Please let's maintain **one** source for this kind of info)
- Recently revised (upward) by Tom Junk with help from FNAL Computing.
- 25-50Hz, 5ms, 6APA, 2-4$\times$ compression, 25-50M events.
- 25-50TB buffer disk, 30-60 parallel HDD writes, 1.5-3.0 GByte/sec.
  - Instantaneous - but taking just as many cosmics as beam between spills!
- What processing, where?
  - Huffman encoding? Initial software noise filtering? Signal processing (response deconvolution)?

To handle this data, I wonder: **what computing and networking elements are needed, of what type, how many and how are they interconnected?**

There is a relatively high level of complexity, the assumptions have spanned at least an order of magnitude, and keep changing $\Rightarrow$ need an efficient and quantitative way to explore the configuration space.

$\rightarrow$ Simulation!

Conceptual System Model



Logically, the graph is made of fully-connected layers.
Physically, there are switch, NIC and computer constraints.

Model joint online/offline context as *directed acyclic graph* of *functional nodes* consuming, processing and producing *discrete units of data*.

The scope of the model may include:

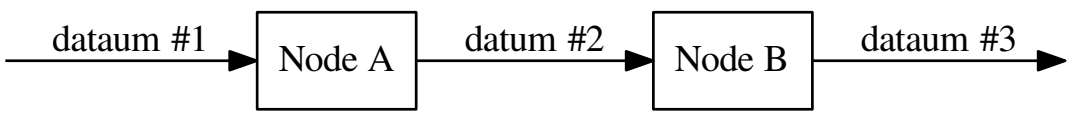
- Digital readout electronics,
- DAQ elements (ie, artDAQ nodes),
- Buffer storage units,
- Prompt processing jobs for QA/QC/commissioning.
- Networking, SA TA bus.

→ don't care about the actual content of data or processing just data sizes, rates, processing time, etc.

Data model

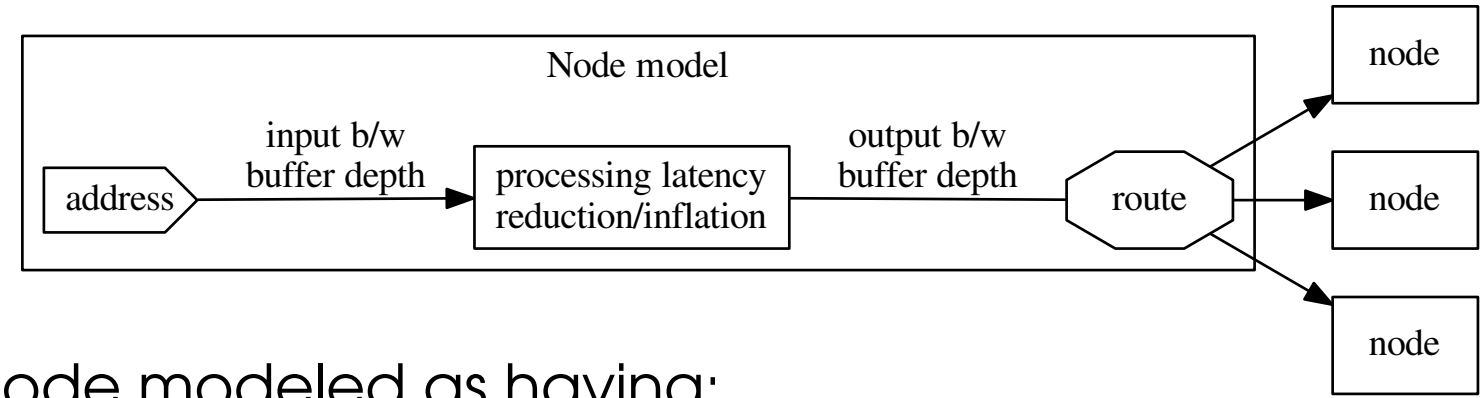
Datum[1] *a single piece of information; especially a piece of information obtained by observation or experiment; – used mostly in the plural.* – Except here, it really is singular!

- A **unit of data is discrete**, no open ended streams.
- Examples:
  - A fragment of a readout from a Board Reader
  - A single readout from an Event Builder
- A datum has effectively **just two numbers**:
  1. a size in Bytes
  2. an identifier.
- Lifetime: produced by one node, consumed by another.



[1] gcide v.0.48

Node model



Each node modeled as having:

- An **address**
- **Input bandwidth** limit and datum **buffer depth**.
- Per-datum **processing latency**.
- Data **reduction/inflation** factor.
- **Output bandwidth** limit and datum **buffer depth**.
- A **routing strategy** for addressing output datum to a downstream node.

Notes:

- Switch bandwidth still applies, but node doesn't "care".
- One node is not (necessarily) equated with one computer host.

Host model

Model a computer box.

- May constrain one or more nodes.
- Assert NIC RX/TX maximum bandwidth constraints.
- Restrict number of node I/O buffers (aka RAM constraint).
- Limit minimum processing time (aka CPU constraint).

Switch model

Model a network switch:

- Full-duplex, infinite switch fabric bandwidth.
- Bandwidth limited at both RX and TX ports (eg, @ 1Gbps).
- Shared bandwidth.
  - Invented a simple, iterative load balancing algorithm.
  - Simultaneous transfers between shared TX and RX ports.
  - Each stream goes as fast as possible subject to fair-share.
- Preemptive.
  1. Newly initiated transfer interrupts switch.
  2. In-progress transfers updated with the elapsed time.
  3. New stream added and bandwidth load-balanced.
  4. Continue until interrupted or next transfer completes.

(This has been implemented and tested.)

Discrete Event Simulation

Basic idea:

- System state changes in **discrete steps**.
- Changes occur based on an "**event**".
  - Most events in terms of a "**timeout**" primitive.

  → ("do this thing for 3 seconds").
- Change state by executing associated "**event callbacks**".

Example: transfer a datum on a network link:

1. Get available bandwidth and fixed latency for the link.
2. Get the size of the datum.
3. Set **timeout**(`now + latency + size/bandwidth`).
4. Raise event "transfer complete" and trigger associated callbacks.

→ tl;dr: focus on connecting detailed, local event callbacks and let the system work out the overall complex behavior.

Ersatz

`https://github.com/brettviren/ersatz`

- Based on SimPy 3 and Python 3.
  - Asynchronous co-routines but single-threaded.
  - Python generators and heavy use of `yield`.
- **Ersatz** package provides now, (or will Real Soon Now):
  - A shared bandwidth, preemptive network switch (done).
  - Generic, parametrized node (started).
  - Graph description and layout (todo).
  - Configuration and command line interface (started).
  - State monitoring and visualization services (rudimentary).
  - Many unit tests and examples (already)
  - Documentation (lagging)

Developers welcome. Users need to wait a bit.

Watch this space.