

GNU Radio 4.0:
Packet<T> → Tensor<T> → `DataSet<T>` - 2nd Round

handling of chunked data + meta-information (↔ transient recording, data-multiplexing, non-RF signals e.g. matrix/image/tensors…)

`(1)`*#6182* expressing signal measurement errors/confidence intervals

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`(2)#----` synchronising data (streams) from different flow-graphs and nodes

`(3)#----` flow-graph post-processing of chunked data → new ‘meta-data + `std::mdspan<>`’-like data type

A. Krimm, Ralph J. Steinhagen, GNU Radio Meeting – online, 2023-03-23
with input from Josh Mormon & John Sallay

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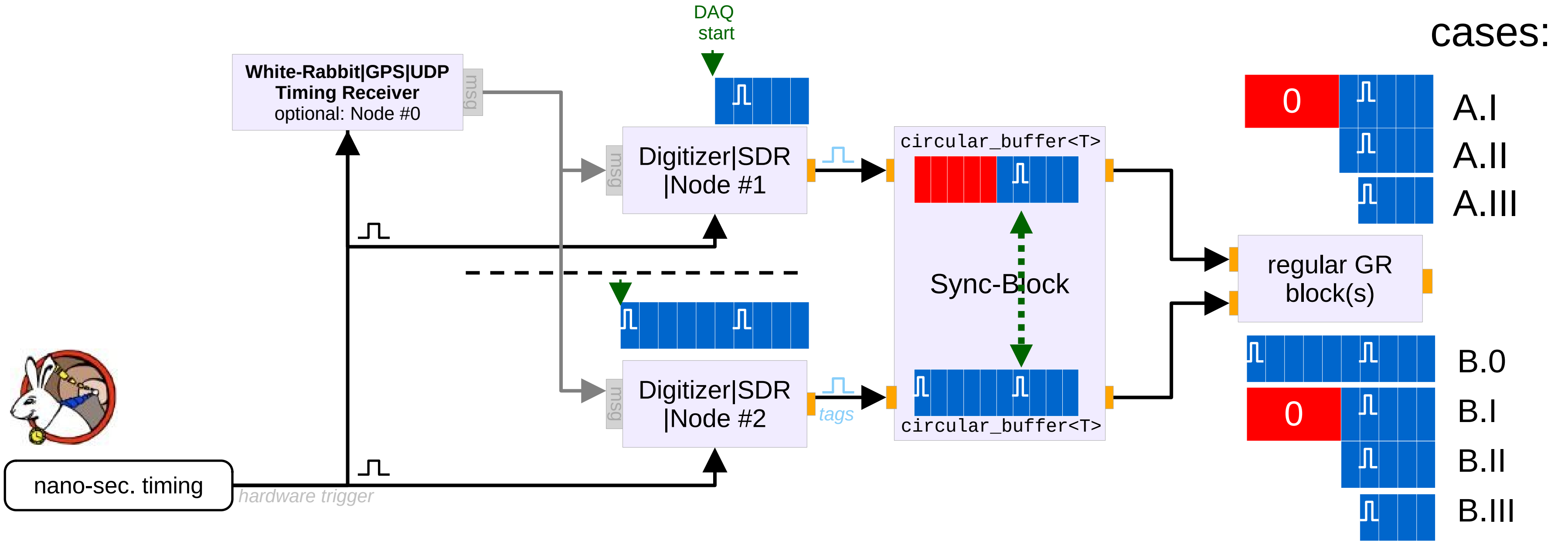
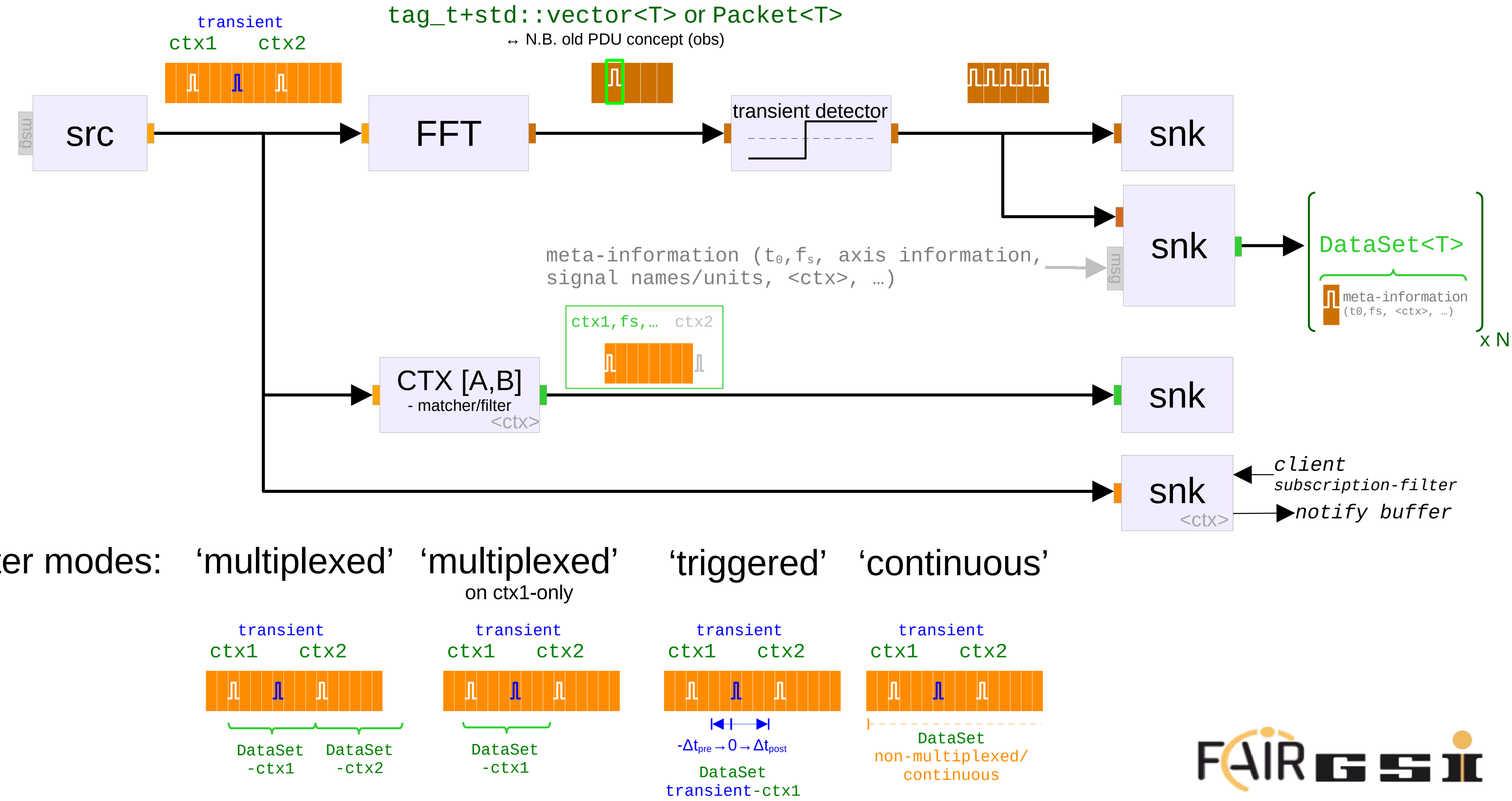
(2) #- - - - synch. data (streams) from different flow-graphs & nodes

- MIMO signals – if possible – are usually synchronised via each RX channel being on the same DAQ system
- not always possible: limited #channel per device (↔costs), largely spacially distributed DAQs (e.g. FAIR: 4.5 km)
- real-world problem: (re-)synchronise physically/spacially distributed sources within the same flow-graph
- failure cases to consider: ‘reconnecting/restarting SDRs/nodes’, ‘no data’ & time-outs, … clock-drifts, transmission delays, ...

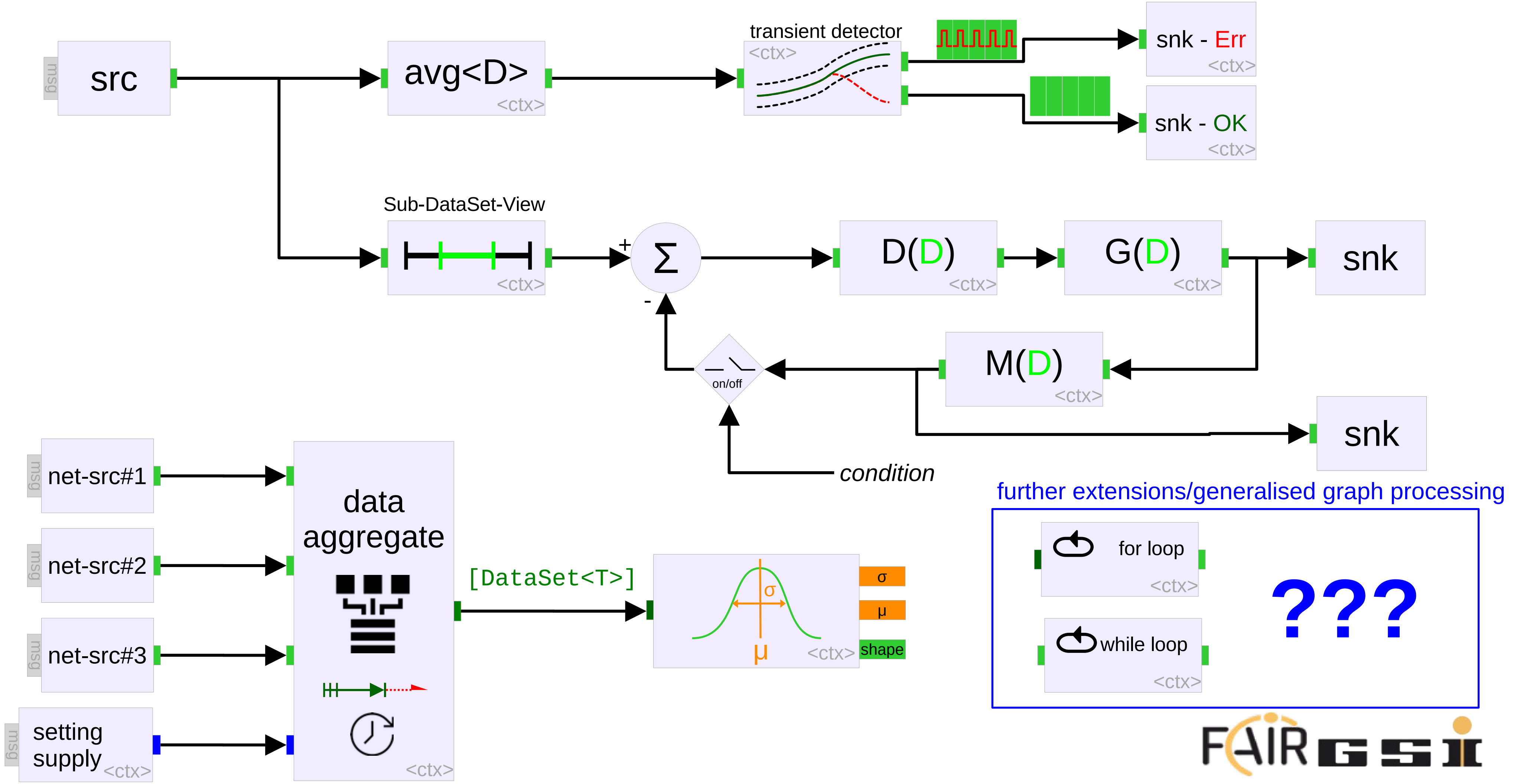


solved through standardised ‘tag_t’s;
TRIGGER_NAME, TRIGGER_TIME,TRIGGER_OFFSET

(3) #- - - - flow-graph post-processing of chunked data → new DataSet<T>



(3) #- - - - flow-graph post-processing of chunked data → new DataSet<T>

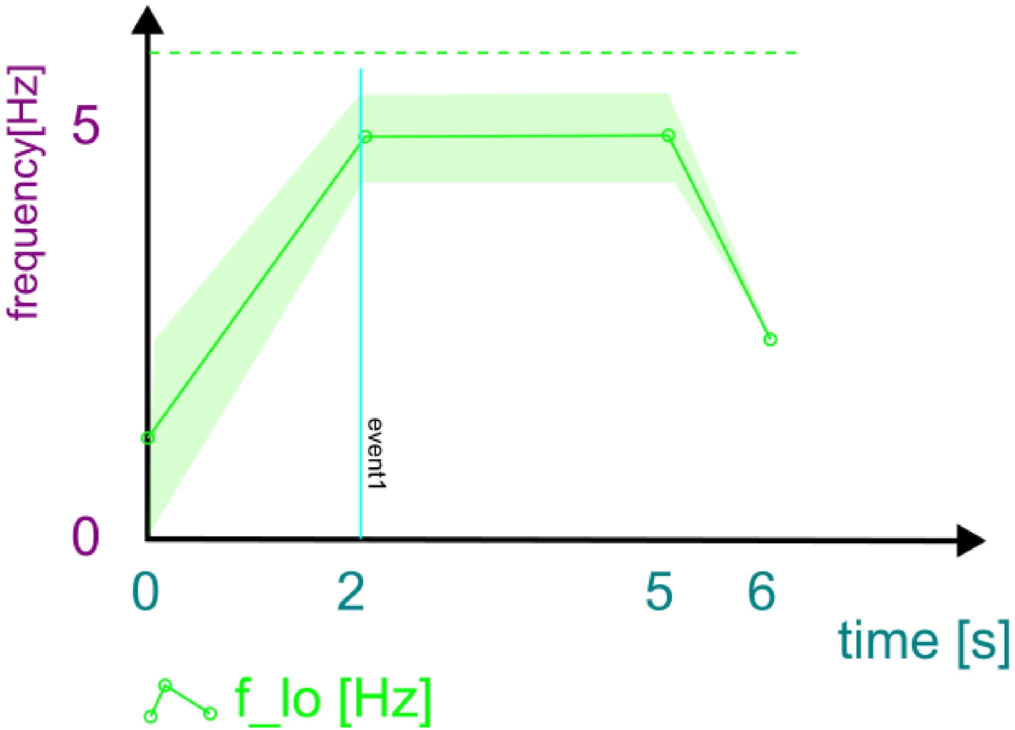


(3) #- - - - three new types → Packet<T> → Tensor<T> → DataSet<T>

```
template<typename T>
struct DataSet { // – numeric/measurement based data (e.g. generation of graphs/plotting)
 Packet
  Tensor
   std::int64_t                                          timestamp = 0; // UTC timestamp [ns]
   // axis layout:
   std::vector<std::string>                              axis_names; // e.g. time, frequency, …
   std::vector<std::string>                              axis_units; // axis base SI-unit
   std::vector<std::vector<T>>                           axis_values; // explicit axis values

   // signal data layout:
   std::vector<std::int32_t>                             extents; // extents[dim0_size, dim1_size, …]
   std::variant<layout_right, layout_left, std::string>  // row-major, column-major, "special"
                                                         layout;

   // signal data storage:
   std::vector<std::string>                              signal_names;  // size = extents[0]
   std::vector<std::string>                              signal_units;  // size = extents[0]
   std::vector<T>                                        signal_values; // size = \PI_i extents[i]
   std::vector<T>                                        signal_errors; // size = \PI_i extents[i]
   std::vector<std::vector<T>>                           signal_ranges; // [[min_0, max_0], [min_1, …]

   // meta data
   std::vector<std::map<std::string, pmt::pmtv>>  meta_information;
   std::vector<std::map<std::int64_t, pmt::pmtv>> timing_events; // ↔ gr::tag_t
   // [..] constructors, accessors, ...
};
```

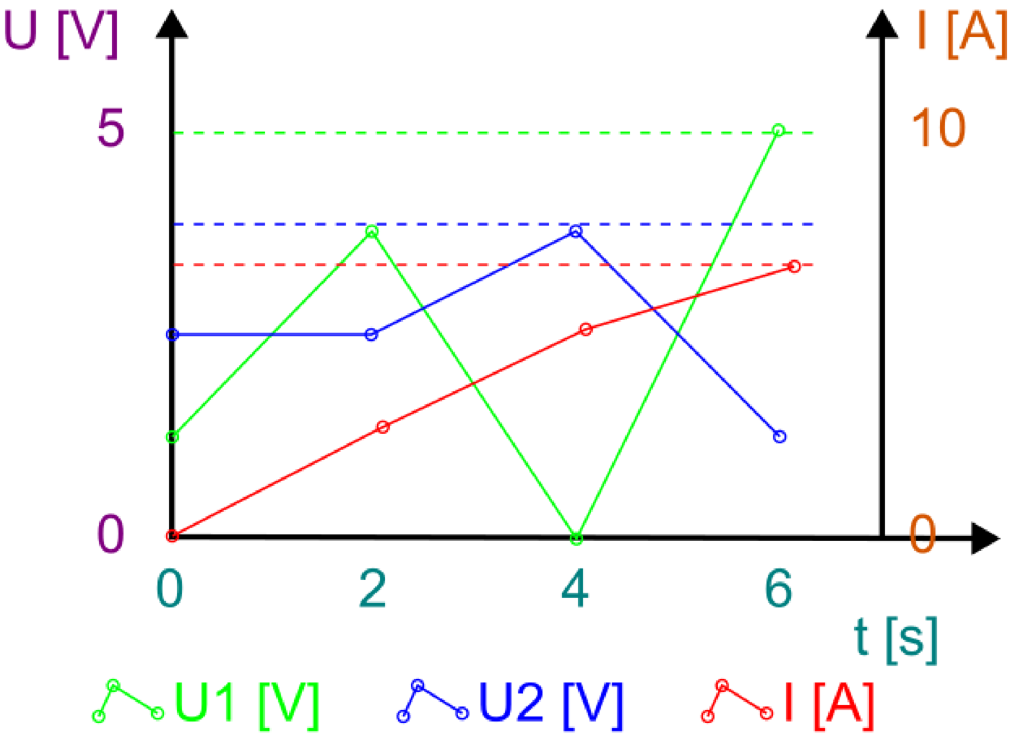
(3) #- - - - DataSet<T> – Example: 1-dim function

```
{
timestamp: 123456789; // [ns]
axis_names: ["time", "frequency"];
axis_units: ["s", "Hz"];
axis_values: [[0, 2, 5, 6], [0, 5]];
extents: [1, 4];
layout: layout_right;
signal_names: ["f_lo"];
signal_units: ["Hz"];
signal_values: [1, 5, 5, 2];
signal_errors: [1, 0.5, 0.5, 0];
signal_ranges: [[0 , 6]];
signal_status: [{"locked": true}];
timing_events: [{123456791: <pmtv>}];
}
```



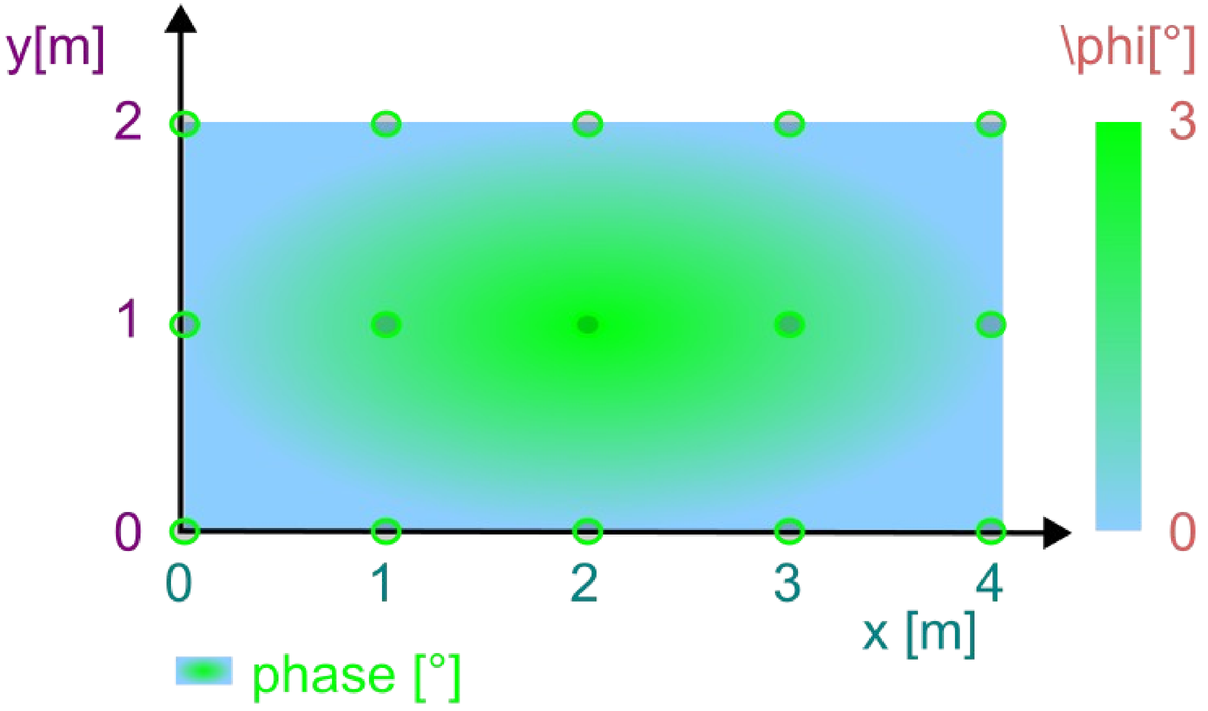
(3) #- - - - DataSet<T> – Example: N=3 x 1-dim function

```
{
timestamp: 123456789; // [ns]
axis_names: ["t", "U", "I"];
axis_units: ["s", "V", "A"];
axis_values: [[0, 6],[0, 5], [0, 10]];
extents: [3, 4];
layout: layout_right;
signal_names: ["U1", "U2", "I"];
signal_units: ["V", "V", "A"];
signal_values: [
  1,3,0,5,
  2,2,3,1,
  0,2,4,5];
signal_errors: [];
signal_ranges: [[0,5],[0,4],[0,5]];
signal_status: [];
timing_events: [];
}
```



(3) #- - - - DataSet<T> – Example: Image/Matrix/Tensor

```
{
timestamp: 123456789; // [ns]
axis_names: ["x", "y", "\phi"];
axis_units: ["m", "m", "°"];
axis_values: [[0, 4], [0, 2]];
extents: [1, 5, 3];
layout: layout_right;
signal_names: ["T"];
signal_units: ["°"];
signal_values: [
  0, 0, 0, 0, 0,
  0, 2, 3, 2, 0,
  0, 0, 0, 0, 0];
signal_errors: [];
signal_ranges: [0,3];
signal_status: [];
timing_events: [];
}
```



(3) #---- Packet<T> → Tensor<T> → DataSet<T> – Summary

- new buffer/ports greatly simplify, unify, and do not need to distinguish between: streams, messages, primitives, PDUs, or (a-)synchronuous communications, → opens new options:
  - gracefully retire old PDUs and other similar types → now: std::vector<T> + tag_t or `Packet<T>`
  - optional choice on ports: single-producer (↔"streaming ports") vs. multi-producer (→"message ports")
  - individual block::work() implementer's choice:
    - synchronous processing → matching number of samples on input ports
    - asynchronous processing → process samples/packets as they arrive

- No 'one size fits all' solution need: `Packet<T>`, `Tensor<T>`, and `DataSet<T>`
  - target 80/20 solution, type-safe, and intuitive usage by new users/novice developers
  - single work function can handle all three use-cases
    N.B. use composition and '`if constexpr ( requires {….} )`' rather than inheritance
  - initial strategy: no in-tree blocks other than:
    - generic math operations: add, subtract, multiply, concatenate, FFT, selector, …
    - merge generic OOT blocks merged as needed

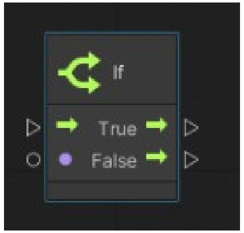
- should differentiate between strict port-types and '`pmt::pmtv`' types
  (N.B. `sizeof(pmtv) == max(sizeof(T)…)`)

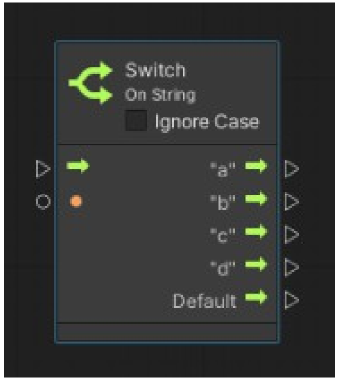
- `do we want support arbitrary user-defined types? e.g. via`
  - `common serialisation protocol (e.g. YAS) or std::map<std::string, pmt::pmtv>`

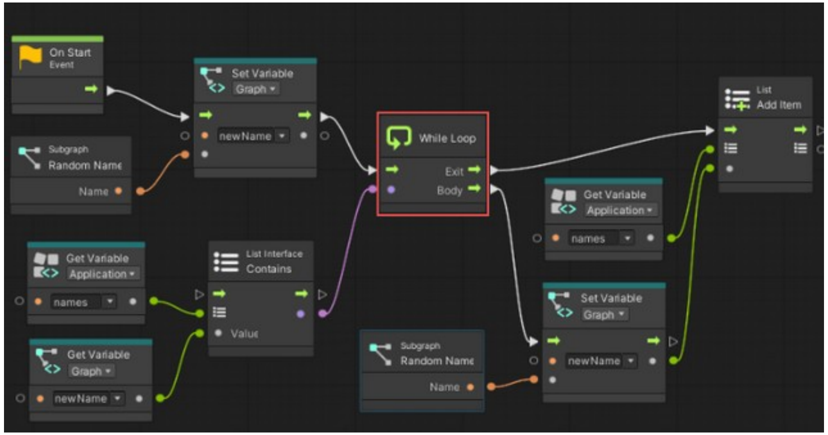
Future Vision/Extension: Inspiration from Unity Control Node …

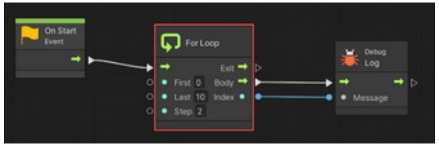
Basic Scripting of more complex signal flow/processing mechanisms

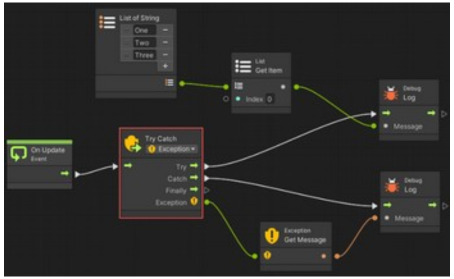
- https://docs.unity3d.com/Packages/com.unity.visualscripting@1.8/manual/vs-control.html

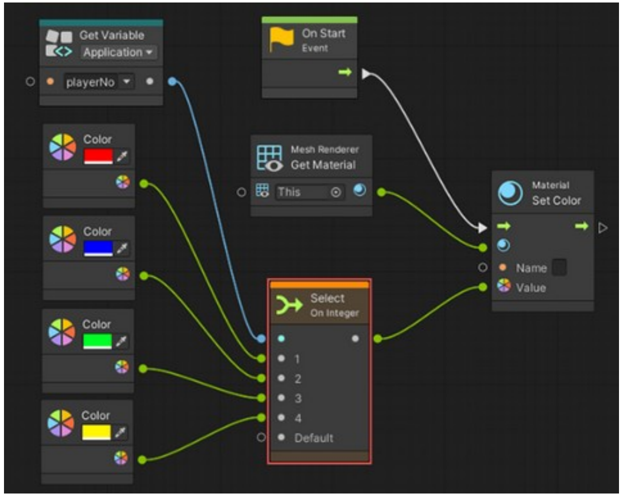


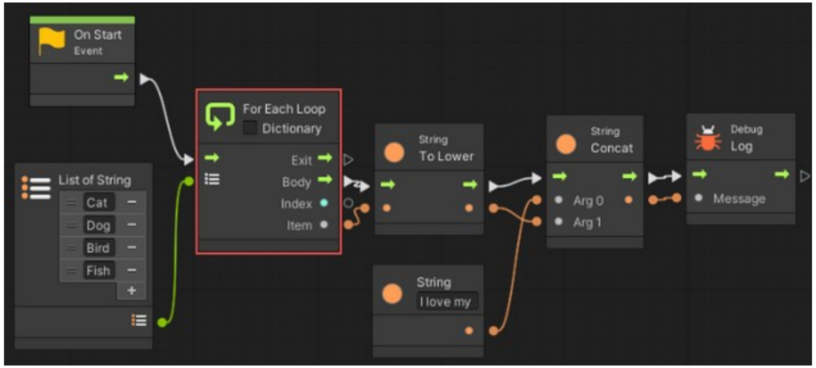


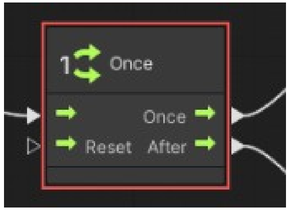


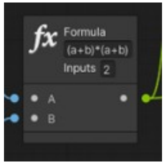


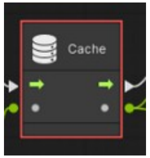












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