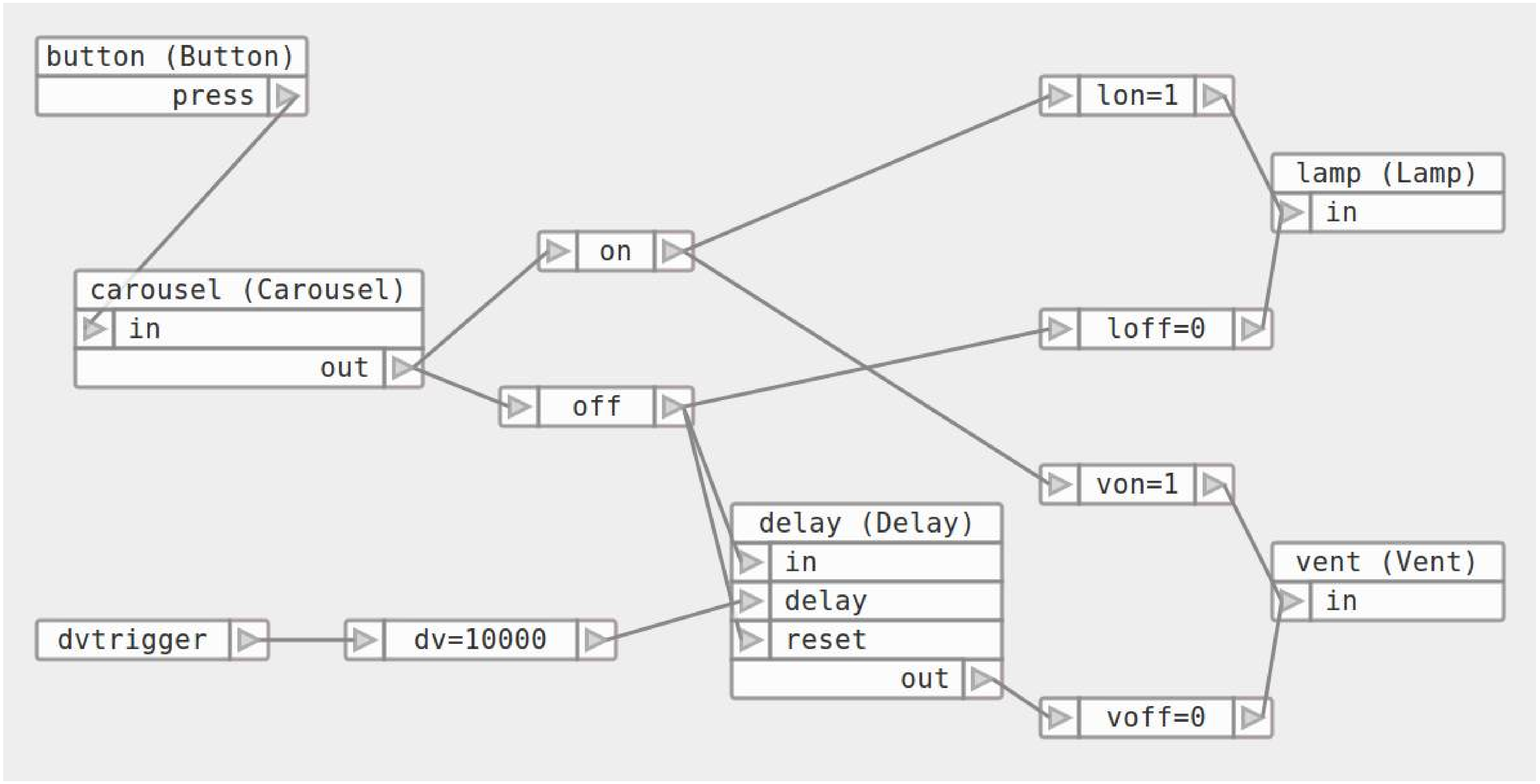
# Dataflow Programming



ern0 - http://linkbroker.hu

## Basics

Definition
Component & Port
Data Types
Source, Processor, Sink

## Advanced

Component: Native vs Composite
Scheduling: Synchronous vs Asynchronous
Triggering: Push vs Pull
Execution: Parallel, Multi Host

## Dataflow Systems

Unix Pipe, Spreadsheet, Make etc.

## Practice

App Creating vs Programming, Component Programming, Application Building

## Benefits

Rapid Prototyping, Reusability, Transparency

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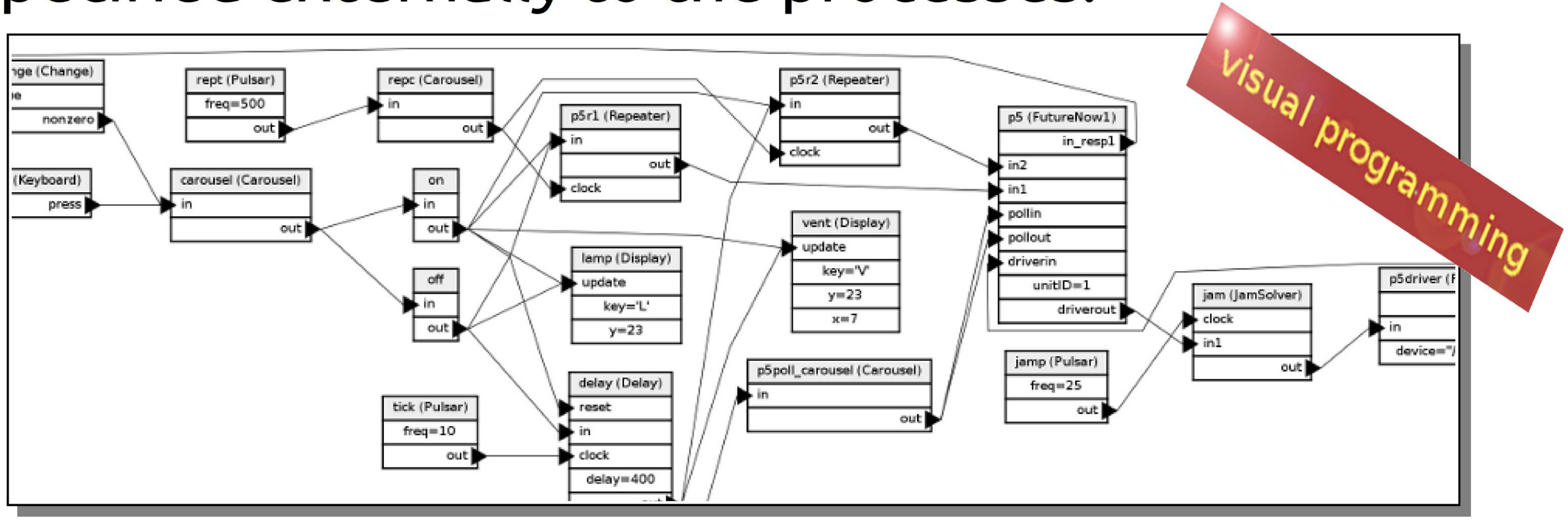
# Definition

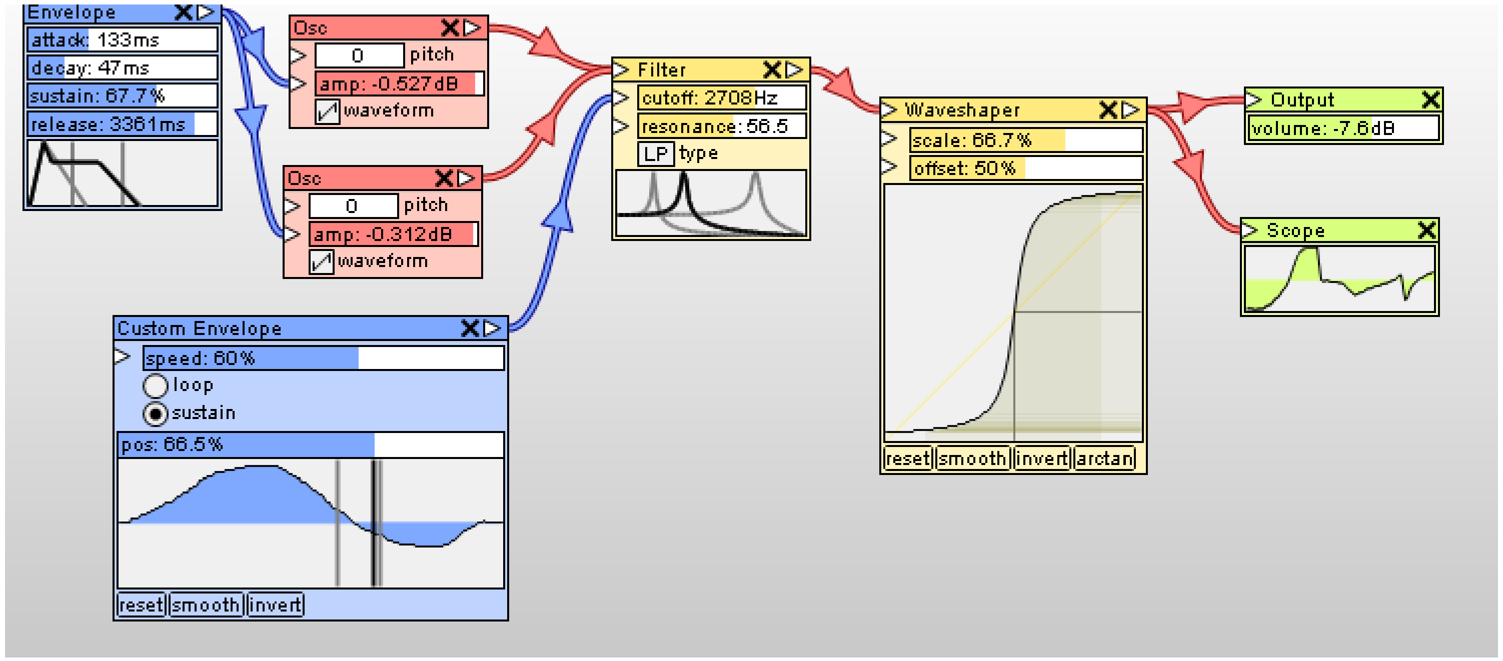
Programming paradigm / software architecture: computation is modelled as a directed graph.

Applications is a network of "black box" processes, which exchange data across predefined connections by message passing, where the connections are specified externally to the processes.



# Domains

- Synth/sampler/workstation
- Audio/video processing
- Animation rendering
- Industrial/home automation
- Spreadsheet
- Task automation


Envelope
attack: 133ms
decay: 47ms
sustain: 67.7%
release: 3361ms

Osc
0 pitch
amp: -0.527dB
waveform

Osc
0 pitch
amp: -0.312dB
waveform

Custom Envelope
speed: 60%
loop
sustain
pos: 66.5%

Filter
cutoff: 2708Hz
resonance: 56.5
LP type

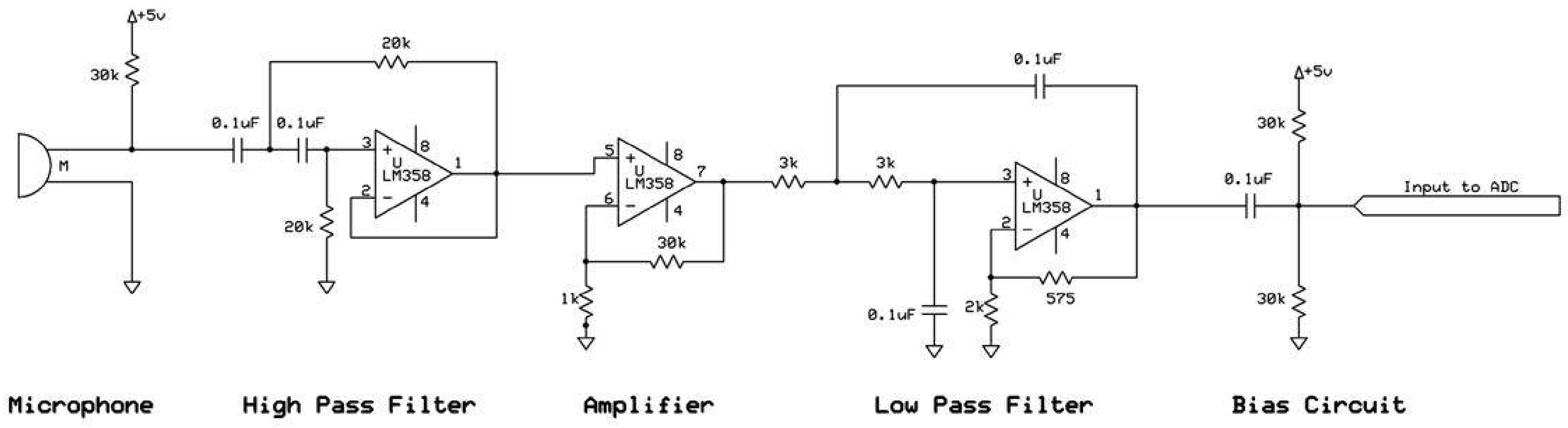
Waveshaper
scale: 66.7%
offset: 50%

Output
volume: -7.6dB

Scope

# Similar, See Also...

Flow Based Programming
Reactive Programming
Functional Programming
Event-Driven Programming
PLC (Ladder Logic, Functional Block Diagram)
**Microservices**
Kahn Process Networks, Petri Net
**Electricity**
etc.



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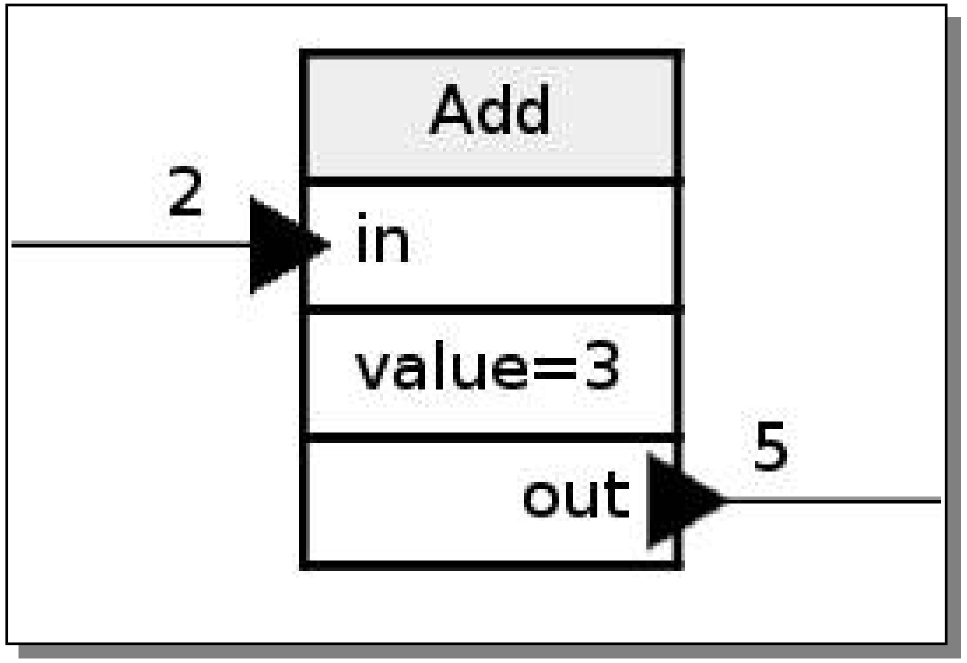
# Component & Port

- consumer (input)
- property
- producer (output)



Component library:
platform, “language”

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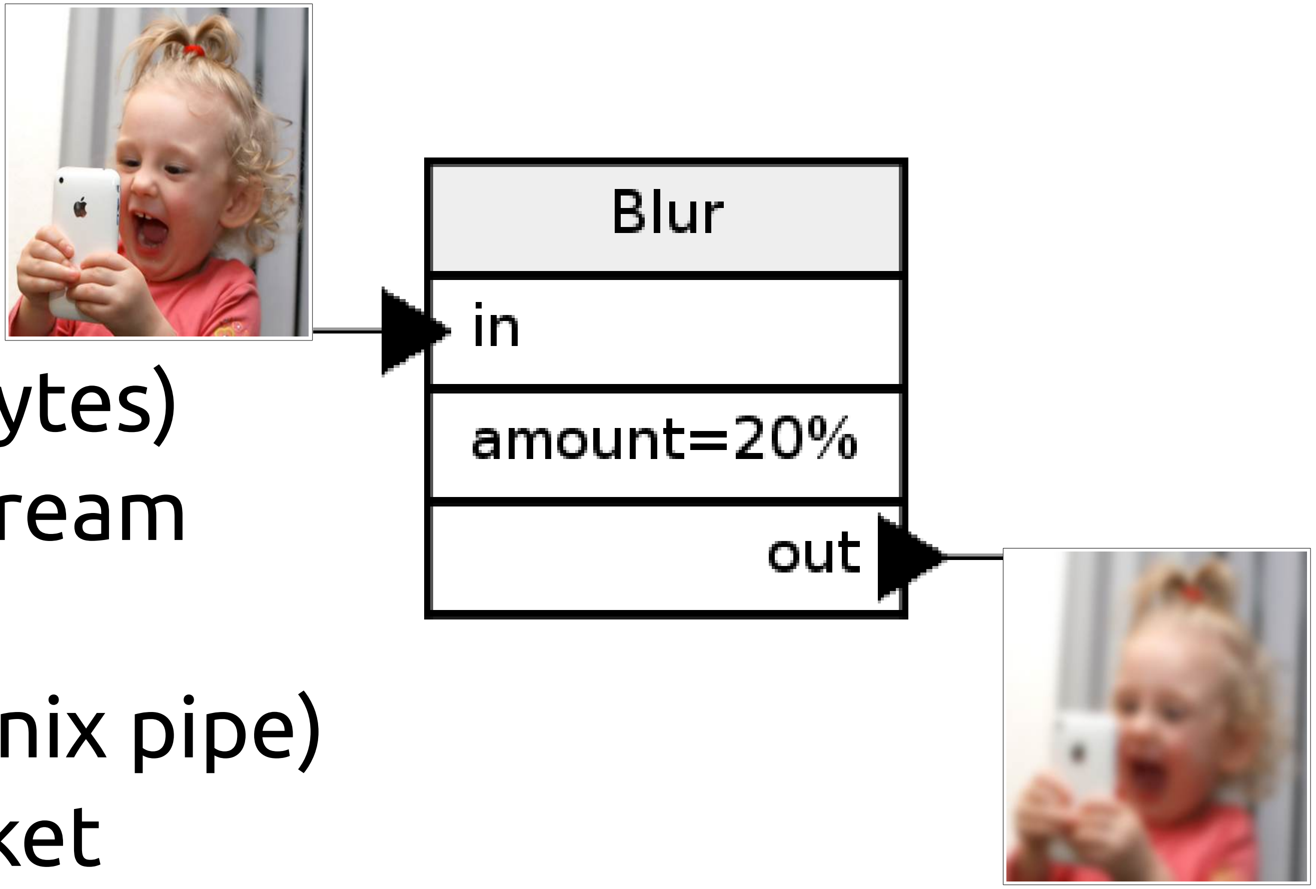
## Data Types

- Trigger
- Integer
- Packet (some bytes)
- Image, video stream
- Audio stream
- Lines of text (Unix pipe)
- Composite packet



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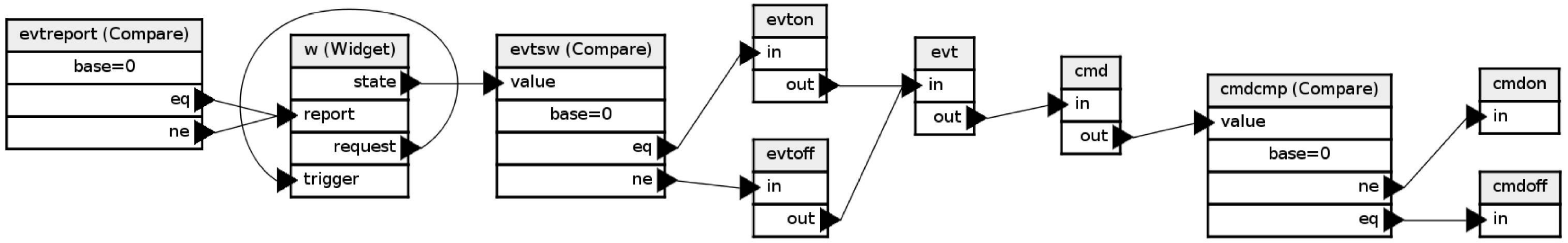
# Component Function Types



| source | processor | sink |
|---|---|---|
| external input | data process | result presentation |
| import, feed | transform | export |
| network receive | path select | network send |
| | process control | |

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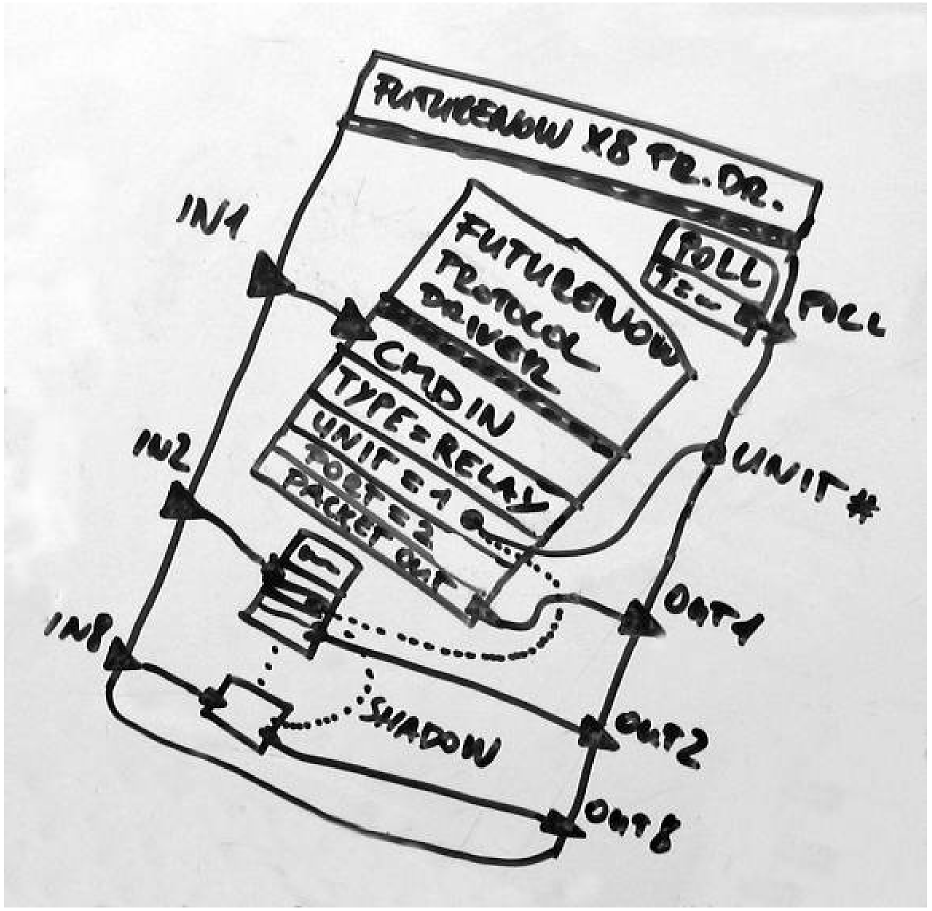
# Component Implementation Modes

## Native

```
class ChangeComponent {

  void messageHandler(Msg* message) {

    int v = message->getValue();
    int l = last->getValue();

    if (v == l) return;
    last->setValue(v);

    changePort->fire(v);

    if (v == 0) {
      zeroPort->fire(v);
    } else {
      nonzeroPort->fire(v);
    }

  } // messageHandler()

} // class
```

## Composite



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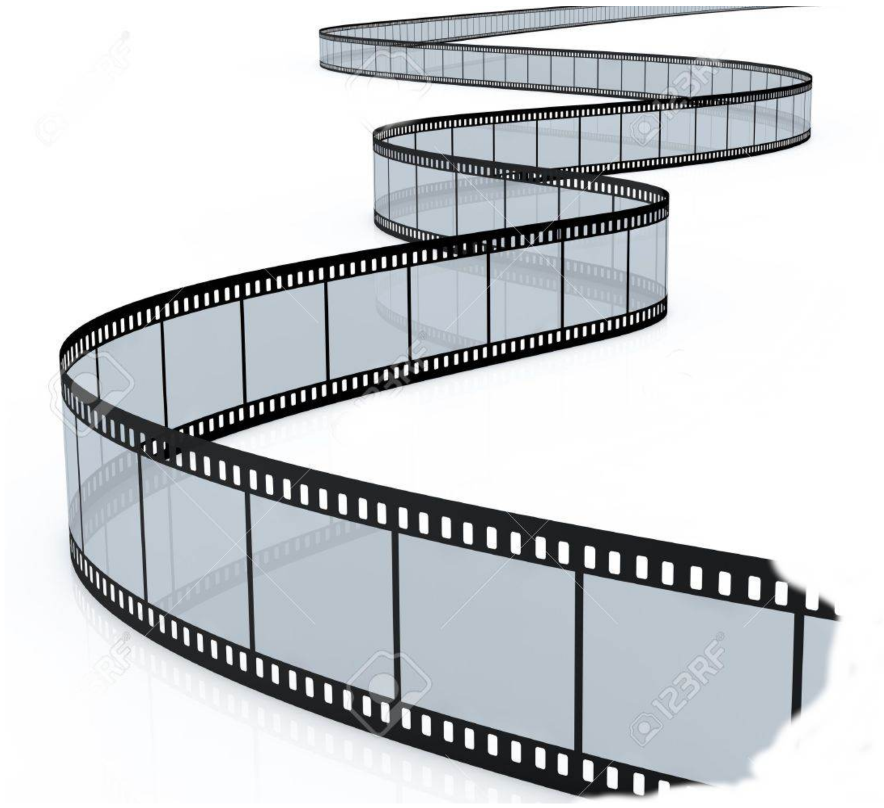
# Scheduling Modes

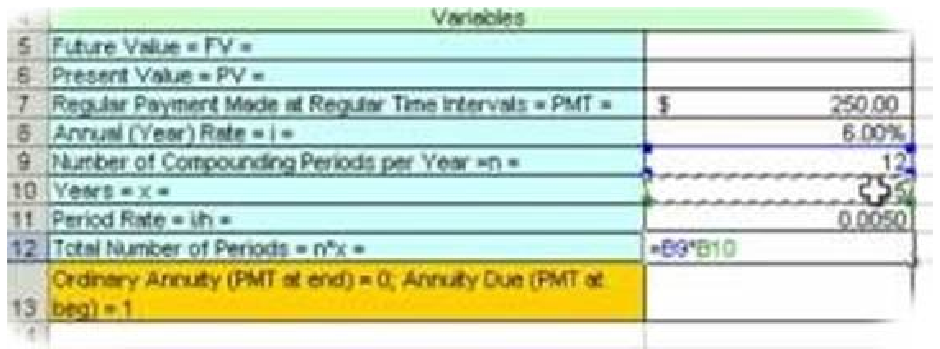
## Synchronous

system clock



## Asynchronous

trigger



| | Variables | |
|---|---|---|
| 5 | Future Value = FV = | |
| 6 | Present Value = PV = | |
| 7 | Regular Payment Made at Regular Time Intervals = PMT = | $ 250.00 |
| 8 | Annual (Year) Rate = i = | 6.00% |
| 9 | Number of Compounding Periods per Year =n = | 12 |
| 10 | Years = x = | 5 |
| 11 | Period Rate = i/n = | 0.0050 |
| 12 | Total Number of Periods = n*x = | =B9*B10 |
| 13 | Ordinary Annuity (PMT at end) = 0; Annuity Due (PMT at beg) = 1 | |

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## Triggering Modes

| Push | Pull |
|---|---|
| data driven | demand driven |
| active source component | passive source component |
| overload, unneeded messages | response delay, improper sampling |

buffering

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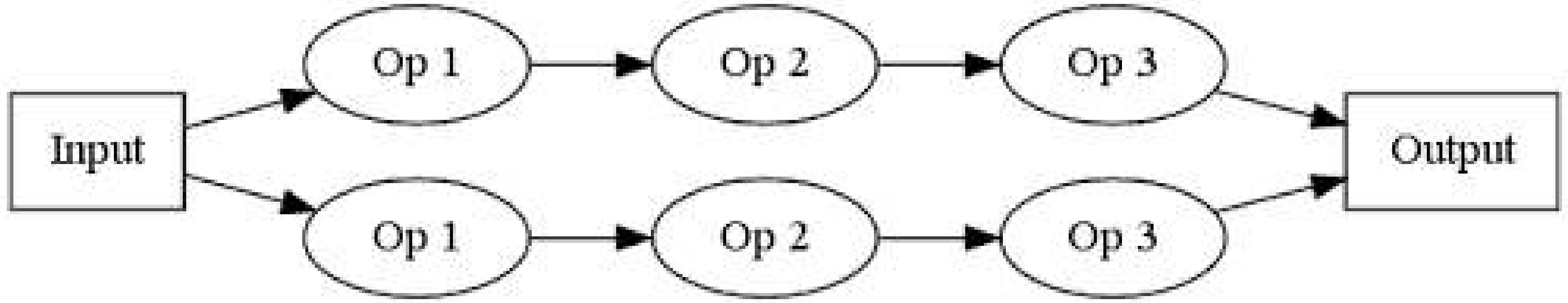
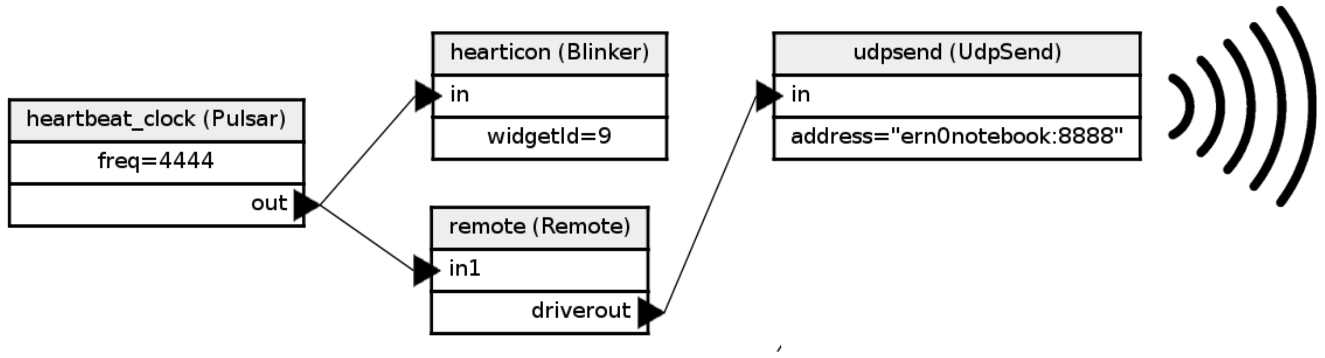
## Parallel Execution

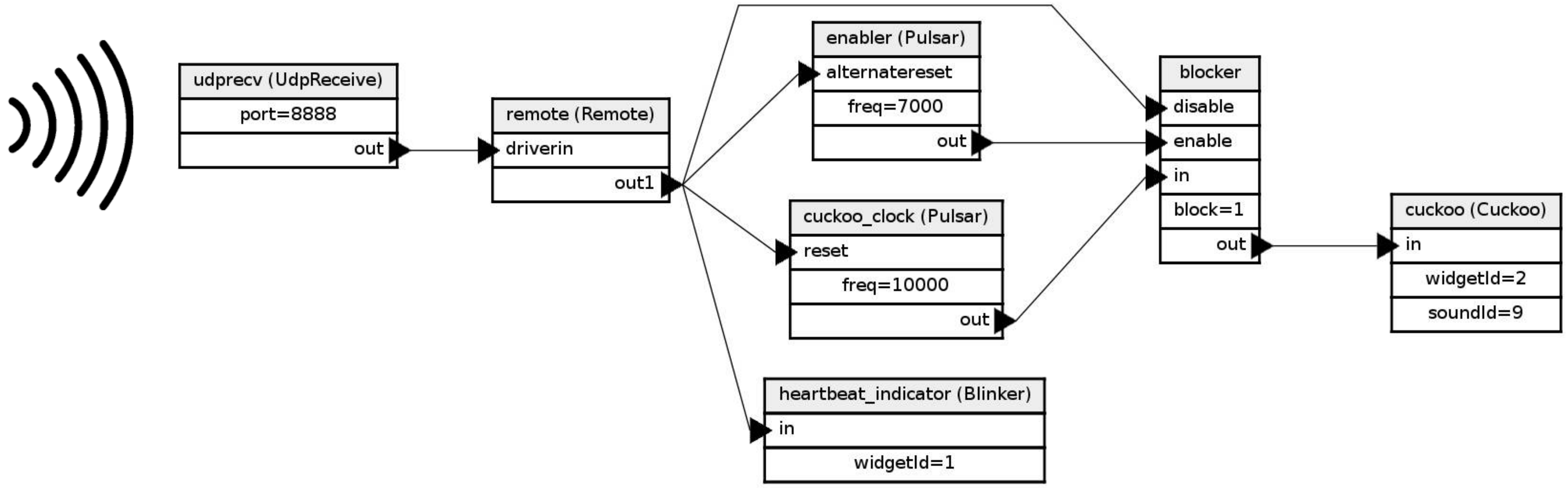


Single-threaded algorhtythms

Problems: load balancing, merging

# Multi-host Application





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**Unix Pipe**, Spreadsheet, Make etc.

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## Unix Pipe

- All the commands are components by default
- One, universal data type: lines of text
- Restricted graph: 1-in-1-out (+ files)
- No editor required, CLI syntax (c1 | c2 | c3)
- Parallel execution (check it: ps)
  (MS-DOS: single, using tmp files)

/bin/cat
/usr/bin/tee

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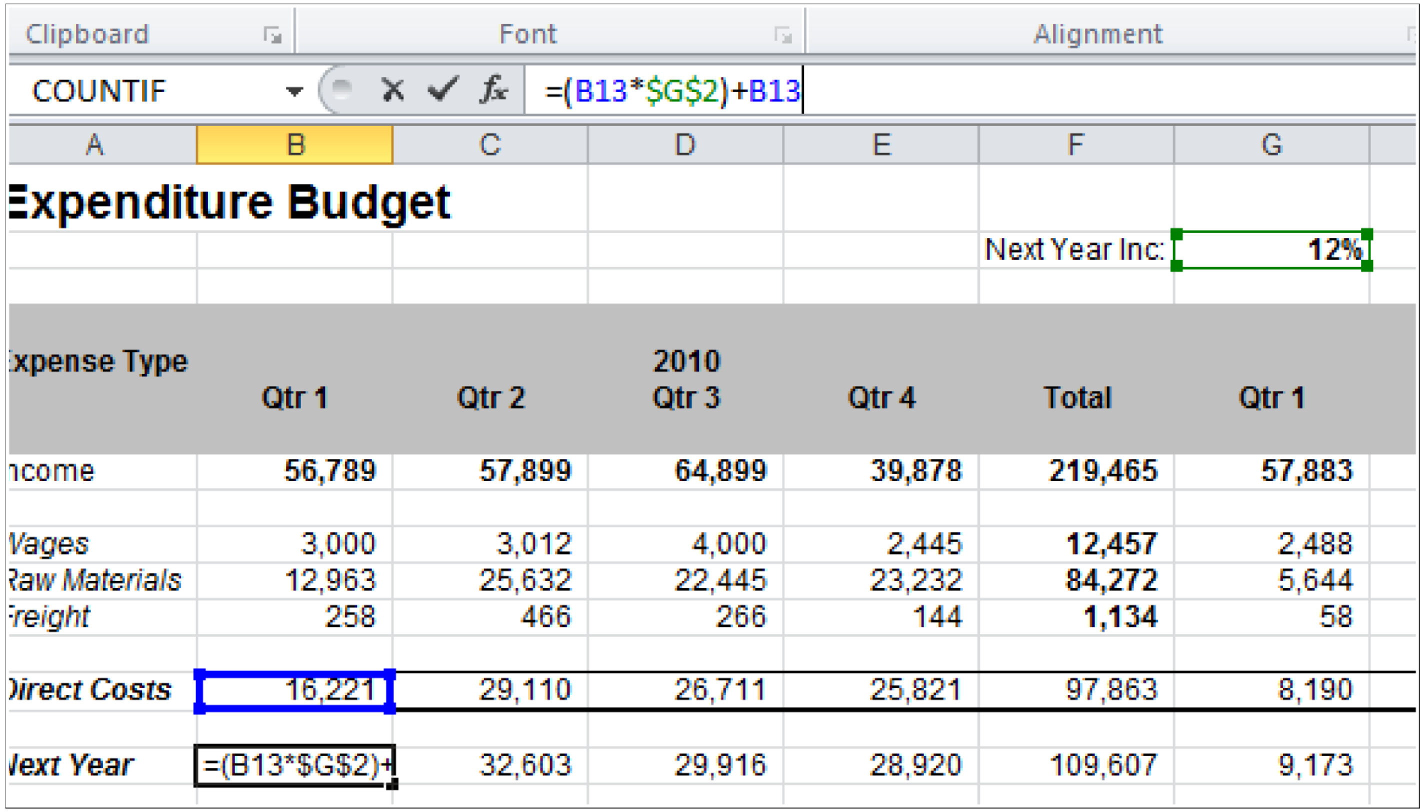
# Spreadsheet

- Formula components (issue: no repository)
- Data types: numeric, date, string
- Graph defined by 2D cell coordinate references



=(B13*$G$2)+B13

| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| | xpenditure Budget | | | | | | |
| | | | | | | Next Year Inc: | 12% |
| | xpense Type | Qtr 1 | Qtr 2 | 2010<br>Qtr 3 | Qtr 4 | Total | Qtr 1 |
| | ncome | 56,789 | 57,899 | 64,899 | 39,878 | 219,465 | 57,883 |
| | Vages | 3,000 | 3,012 | 4,000 | 2,445 | 12,457 | 2,488 |
| | aw Materials | 12,963 | 25,632 | 22,445 | 23,232 | 84,272 | 5,644 |
| | reight | 258 | 466 | 266 | 144 | 1,134 | 58 |
| | irect Costs | 16,221 | 29,110 | 26,711 | 25,821 | 97,863 | 8,190 |
| | ext Year | =(B13*$G$2)+ | 32,603 | 29,916 | 28,920 | 109,607 | 9,173 |

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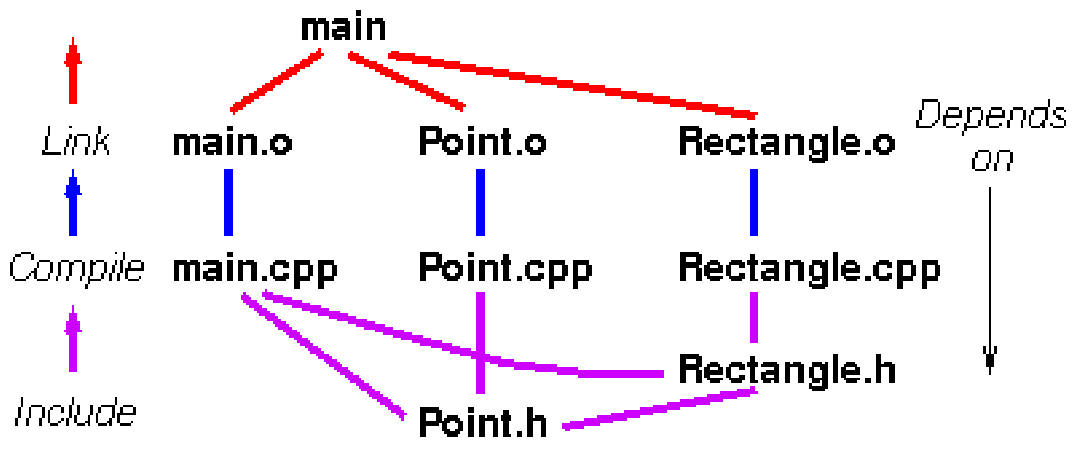
## Make

- Component: job (compiler script)
- Data: file (sources, objects, executable)
- Dependency tree
- Parallel execution
  make -j



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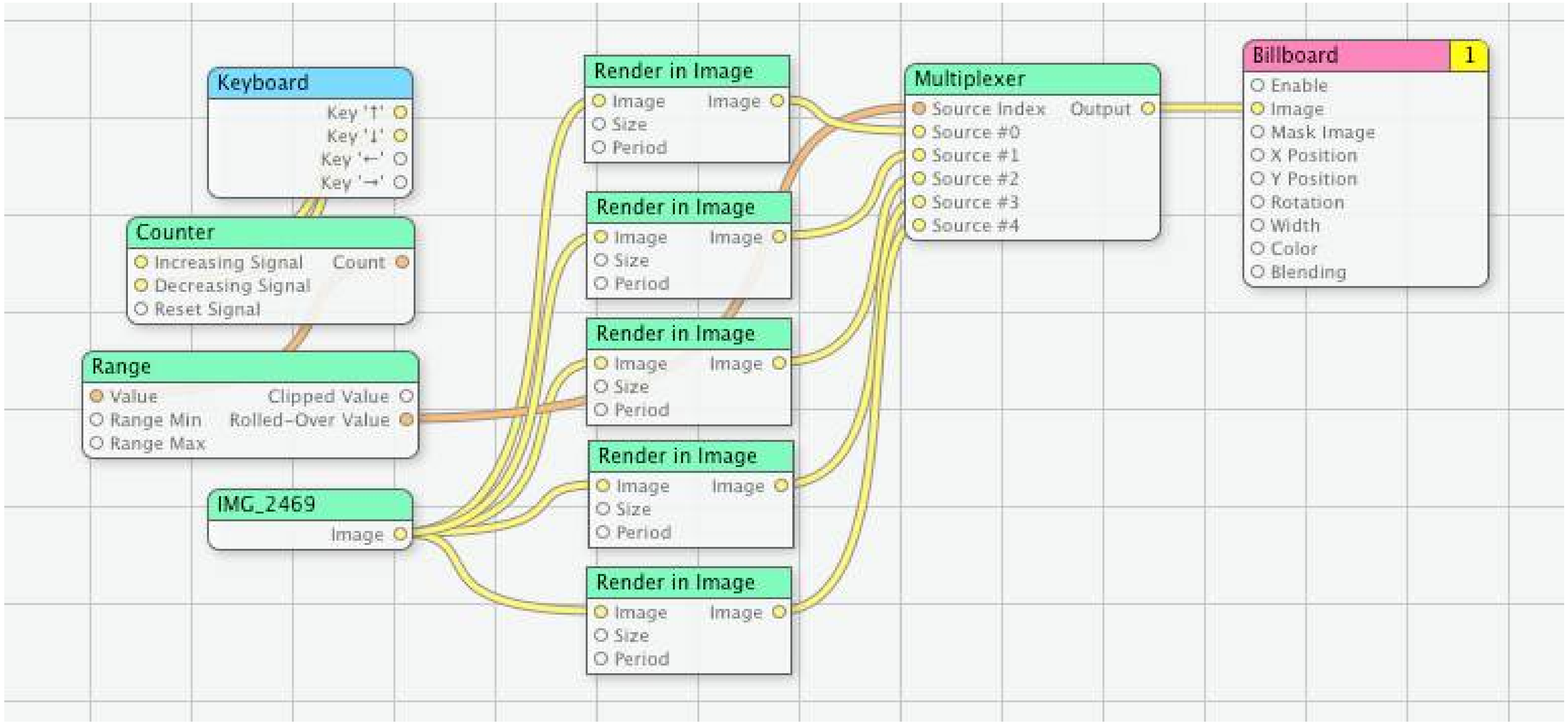
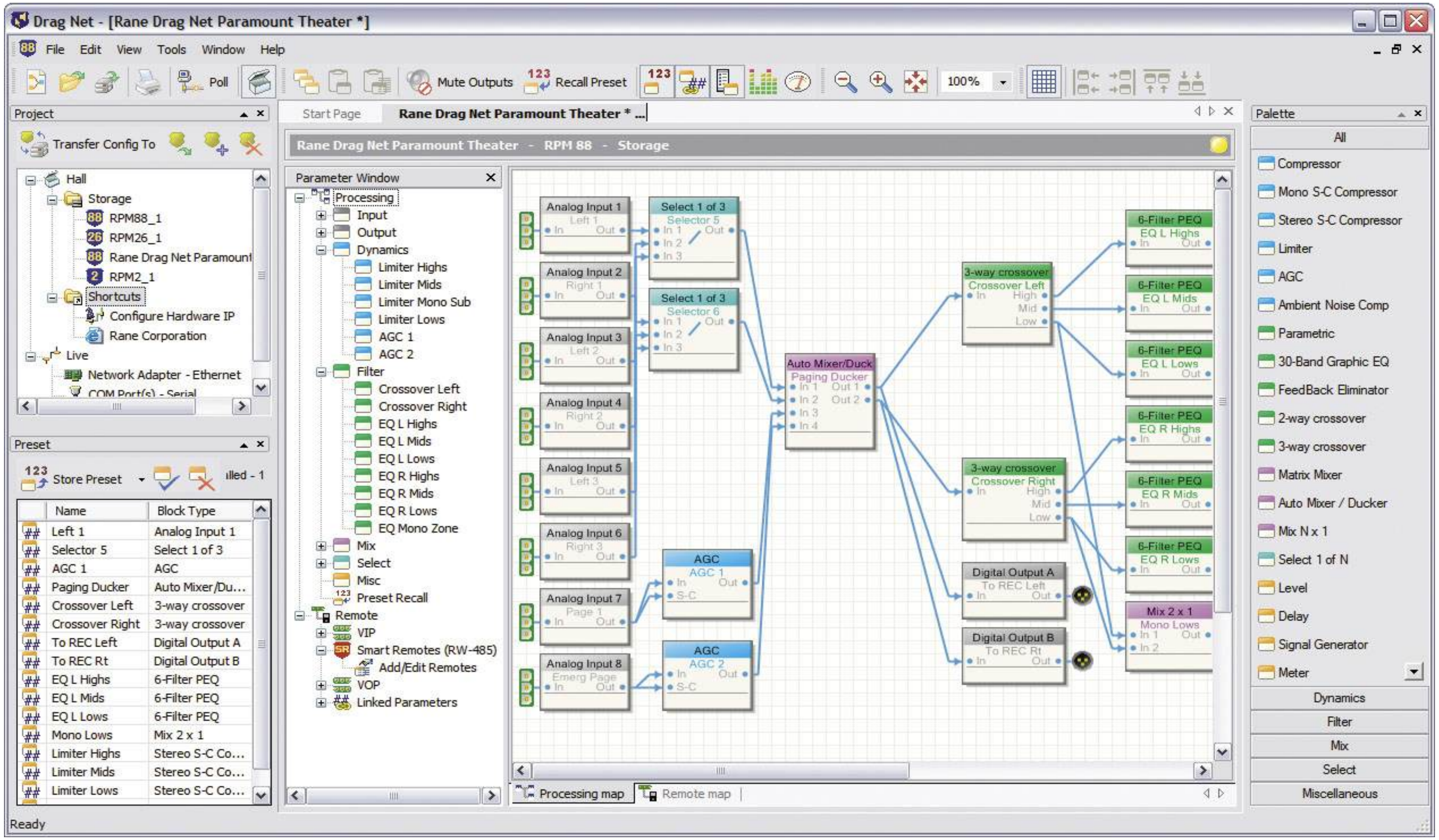
## Quartz Composer

- Graphics purpose
- Comes with Mac OS X



# Rane DragNet

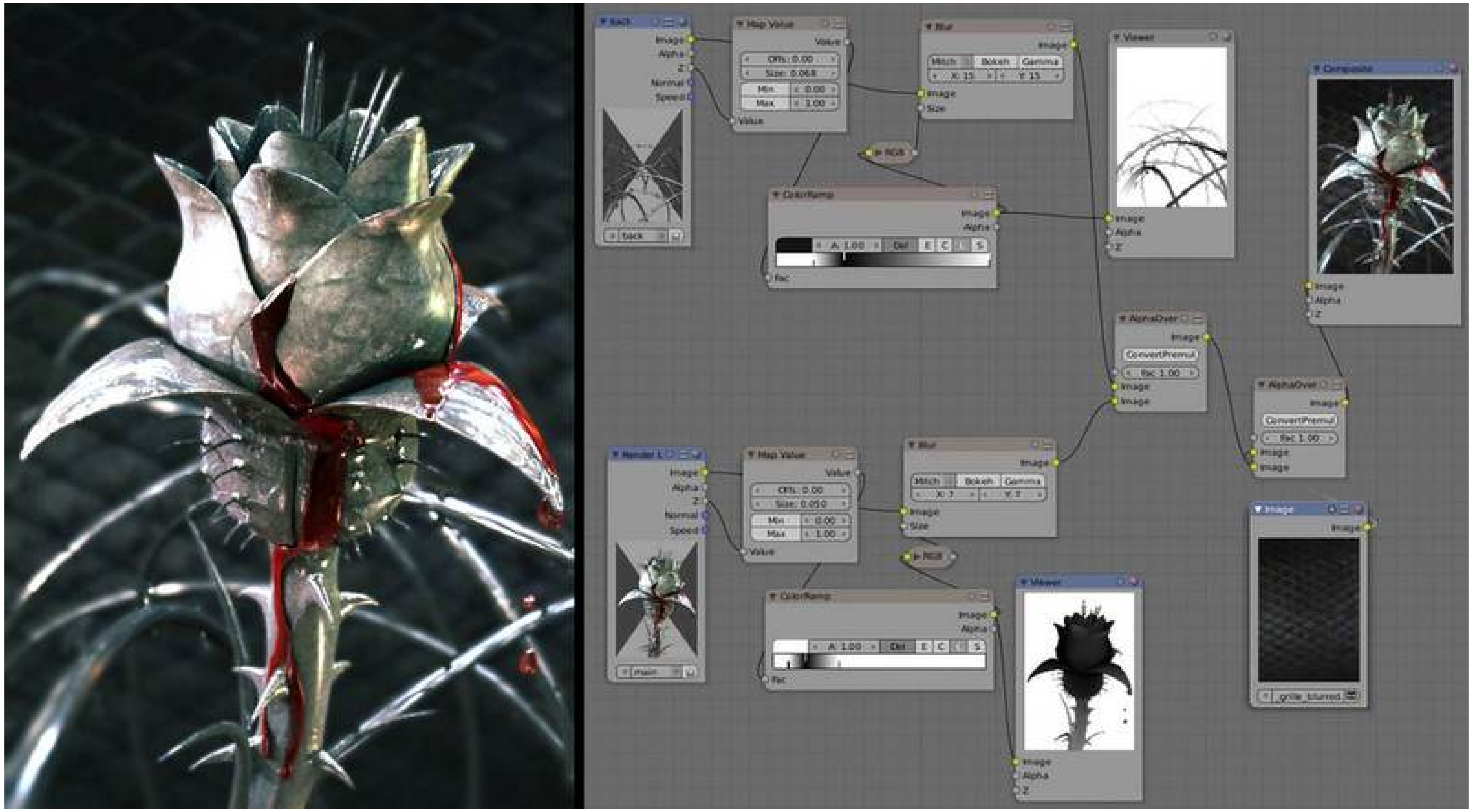
- Audio system



| Name | Block Type |
|---|---|
| Left 1 | Analog Input 1 |
| Selector 5 | Select 1 of 3 |
| AGC 1 | AGC |
| Paging Ducker | Auto Mixer/Du... |
| Crossover Left | 3-way crossover |
| Crossover Right | 3-way crossover |
| To REC Left | Digital Output A |
| To REC Rt | Digital Output B |
| EQ L Highs | 6-Filter PEQ |
| EQ L Mids | 6-Filter PEQ |
| EQ L Lows | 6-Filter PEQ |
| Mono Lows | Mix 2 x 1 |
| Limiter Highs | Stereo S-C Co... |
| Limiter Mids | Stereo S-C Co... |
| Limiter Lows | Stereo S-C Co... |

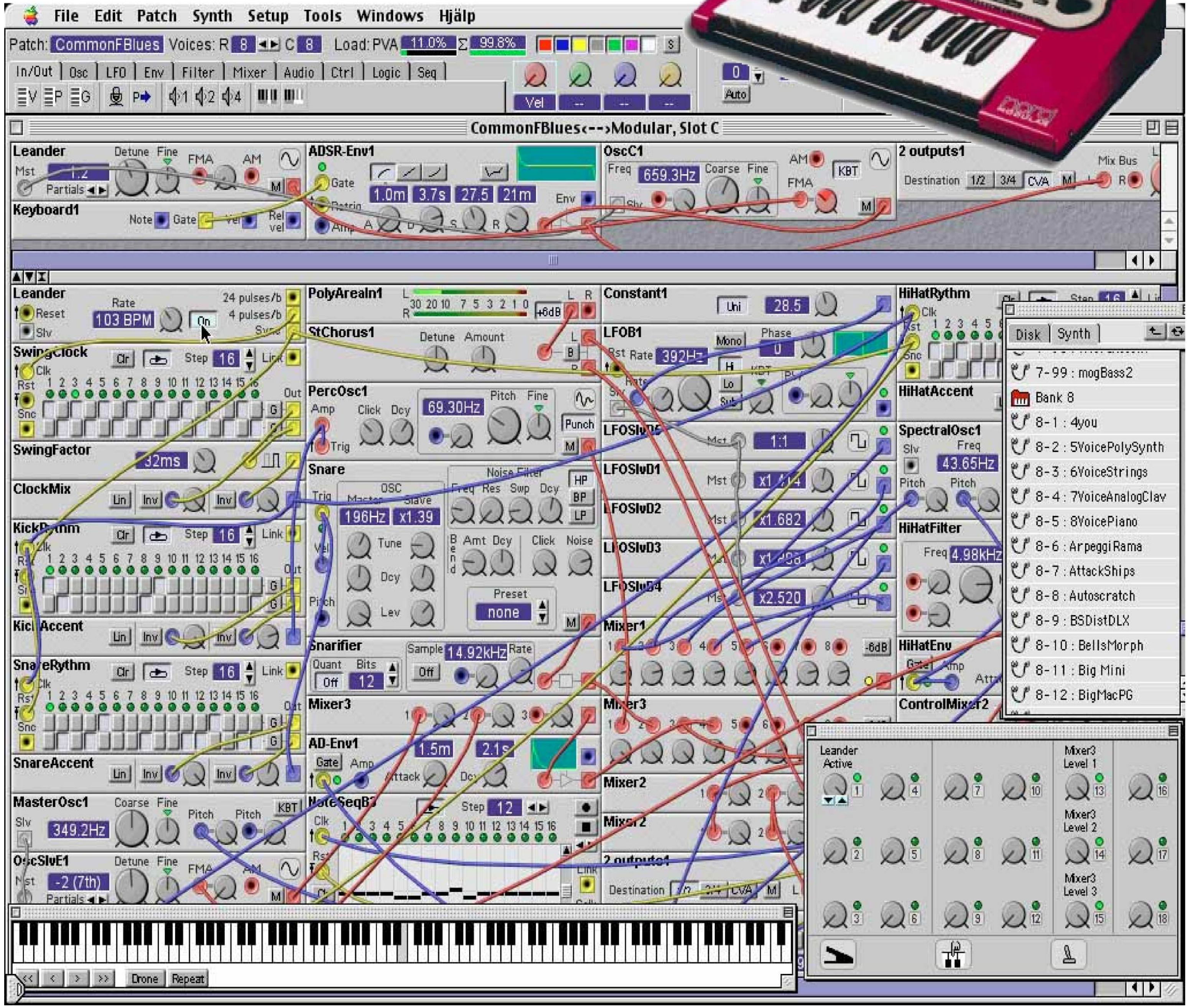
# Blender

- Video system
- Open source



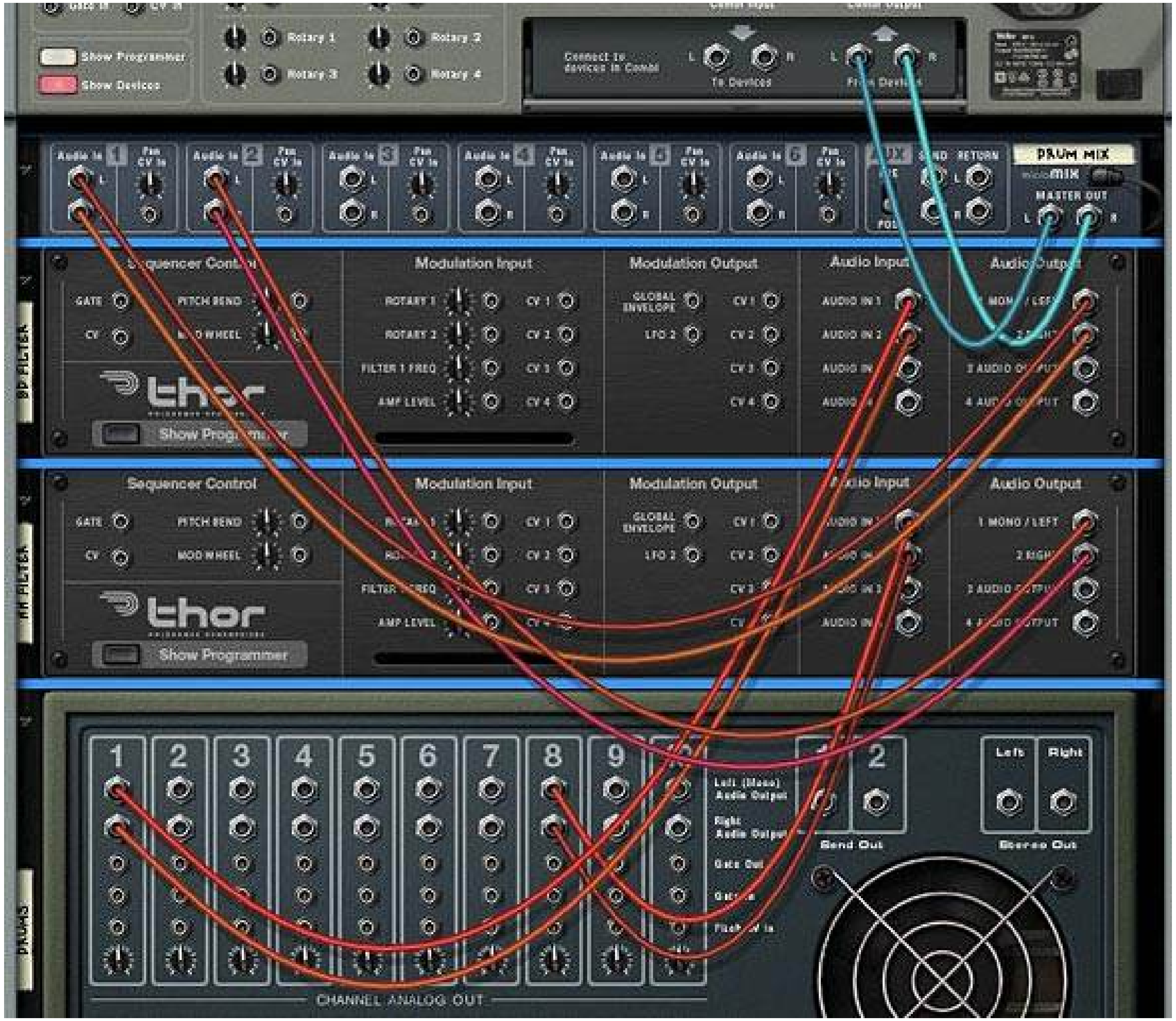
# Clavia Nord Modular

- Music
- Win32 editor



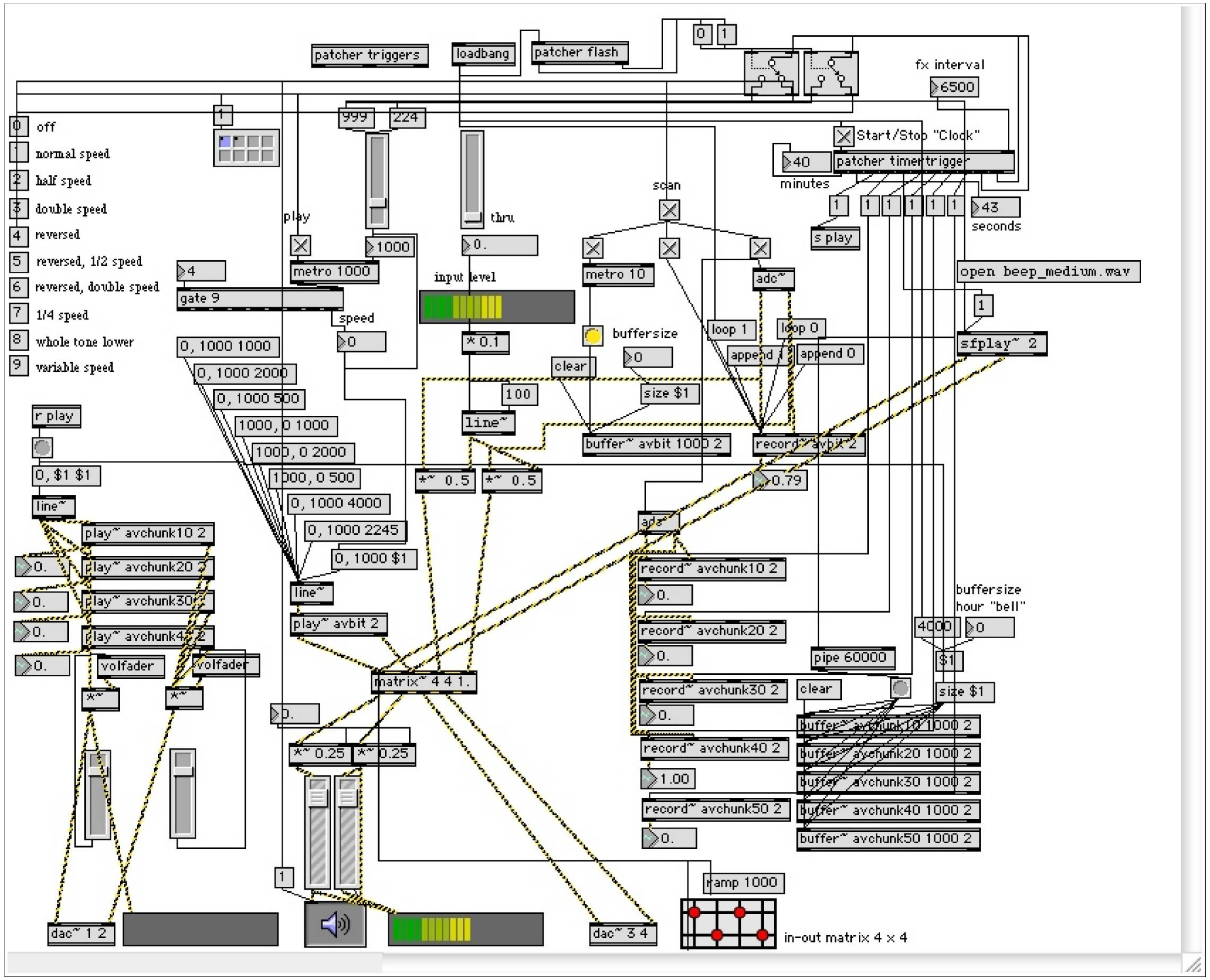
# Propellerhead Reason

- Audio workstation
- Rack+wire metaphor



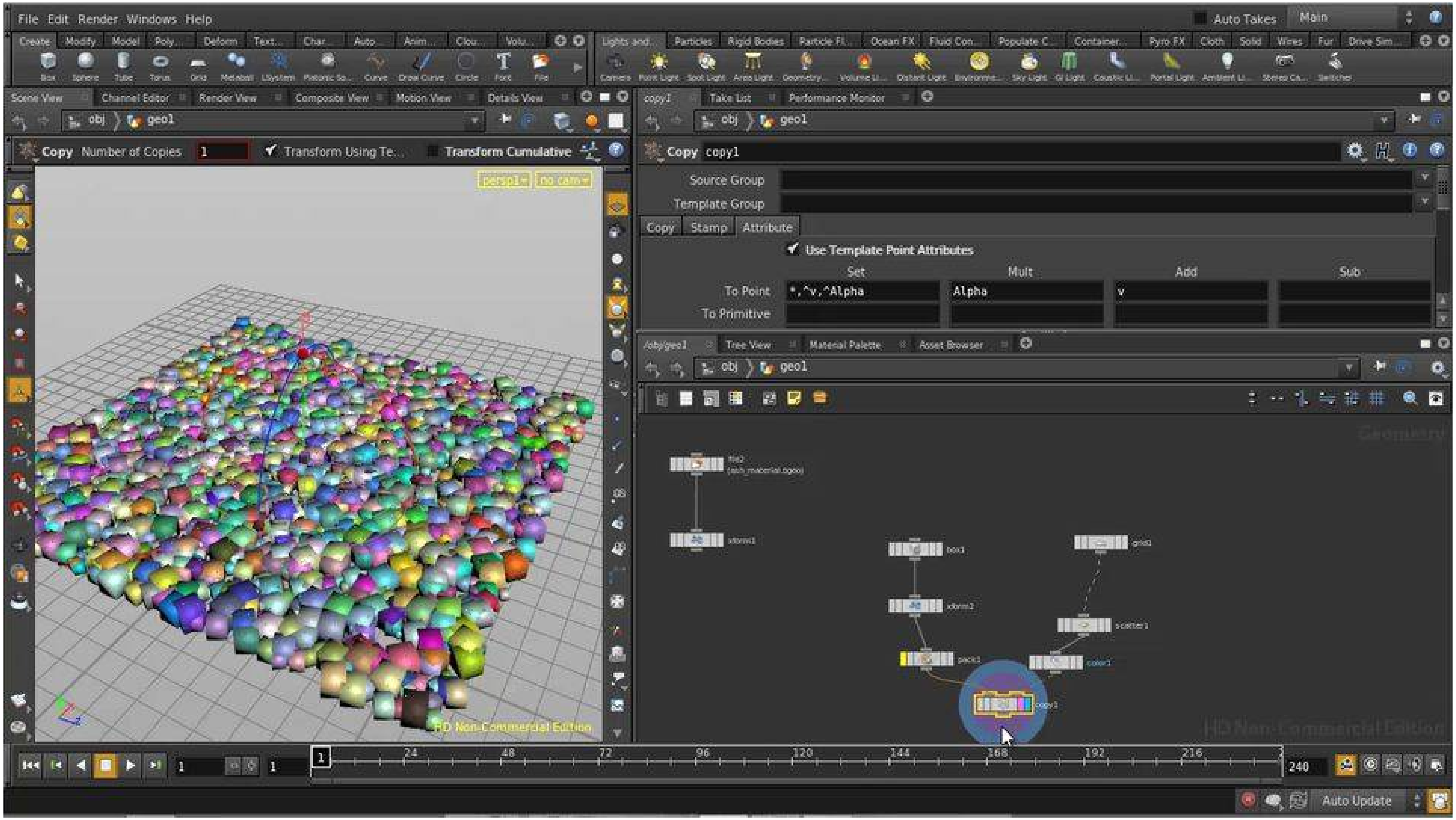
# Max/MSP

Audio/Video



# Houdini

## 3D Animation



# TinyOS

Embedded Systems

```
        // CounterSounder
        Main.StdControl -> CounterSounderM.StdControl;

        // TimerC
        CounterSounderM.Timer -> TimerC.Timer[unique("Timer")];
        Main.StdControl -> TimerC.StdControl;

        // LedsC
        CounterSounderM.Leds -> LedsC.Leds;

        // Sounder
        CounterSounderM.SounderControl -> Sounder.StdControl;
```

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## Good News

creating application $\neq$ programming

## People Are Different

*another image, pls*

# People Are Different

## creating application ≠ programming

| application builder | programmer |
|---|---|
| domain knowledge | **programming** |
| user contact | supporting app builder |
| customization | |
| integration | |
| maintenance | |

separating roles

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# Component Programming

- Simple, small code (100 – 1000 lines)

  Homeaut.com component sizes:

| | |
|---|---|
| JamSolver: | 497 lines |
| Scheduler: | 628 lines |
| SimpleSequencer: | 815 lines |

- Loose coupling: default (Hollywood principle etc.)
- Ready for unit testing
- No customer demands
- No legacy code to fight with

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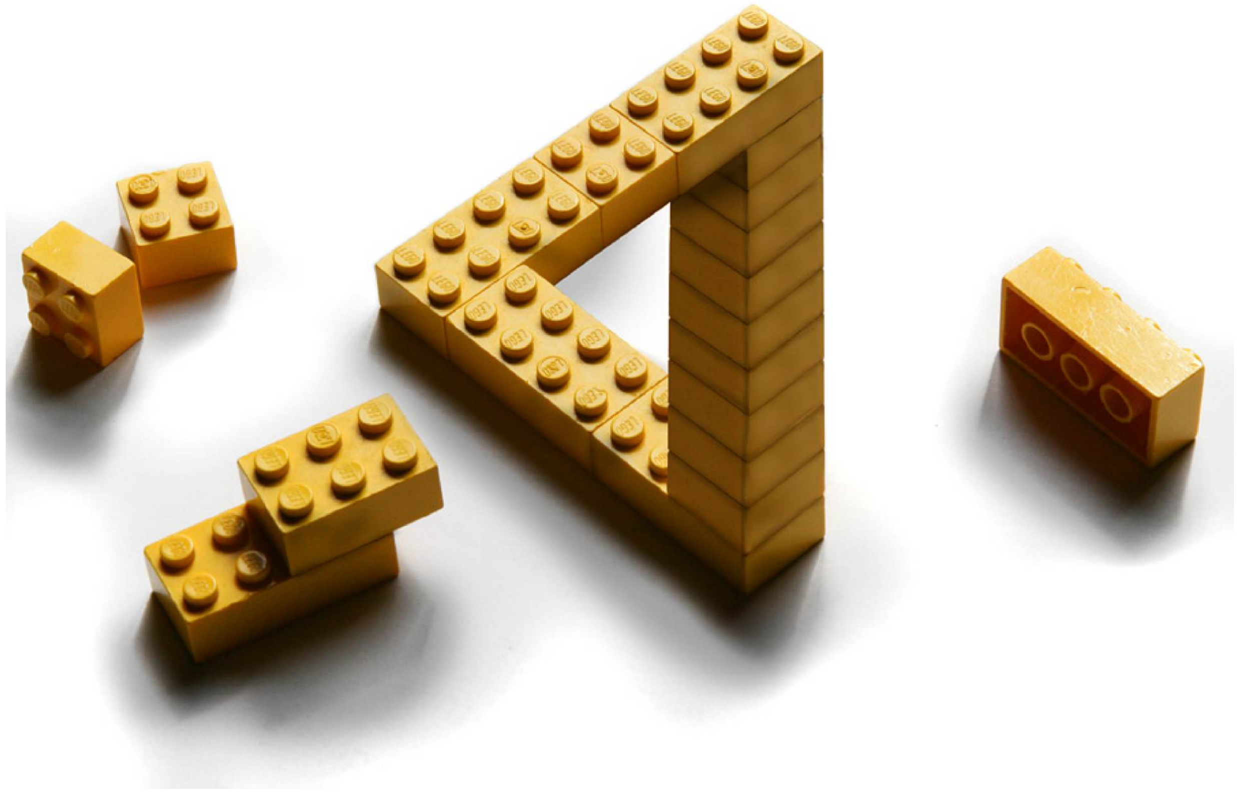
## Application Building

- No programming skills required
- Visual programming
- Convert patterns to composite components
- Focusing on the problem
- Different world



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## Rapid Prototyping

- No programming required
- Mock missing components
- Mock missing resources (data source, user input etc.)
- Discover missing components to be implemented

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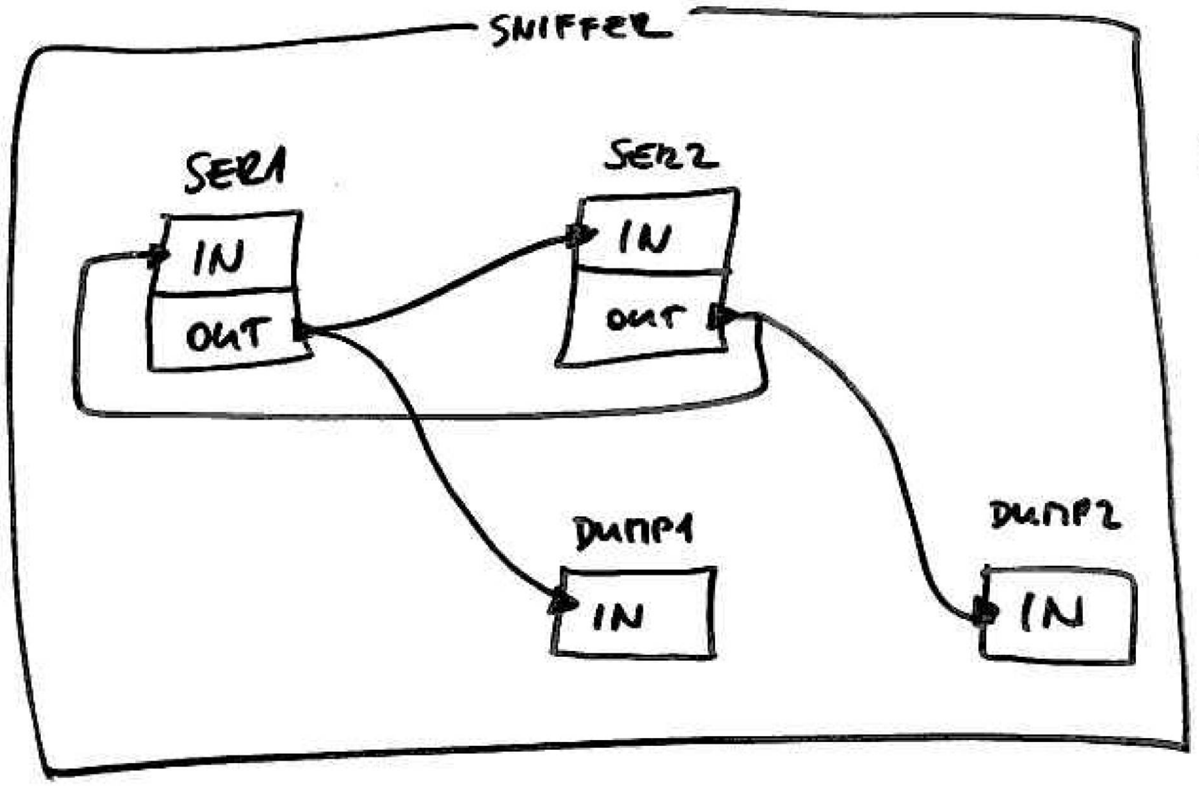
# Reuse. Really.

THE PROJECT I INHERITED HAS WEAK CODE. I NEED TO REWRITE IT FROM SCRATCH.
WILL THERE EVER BE AN ENGINEER WHO SAYS, "THAT LAST GUY DID A GREAT JOB. LET'S KEEP ALL OF IT"?
I'M HOPING THE IDIOT YOU HIRE TO REPLACE ME SAYS THAT.
Dilbert.com DilbertCartoonist@gmail.com
8-12-14 © 2014 Scott Adams, Inc./Dist. by Universal Uclick

OOP promised reusability.
It was a lie.

## Reusability Example

Serial sniffer with home automation components



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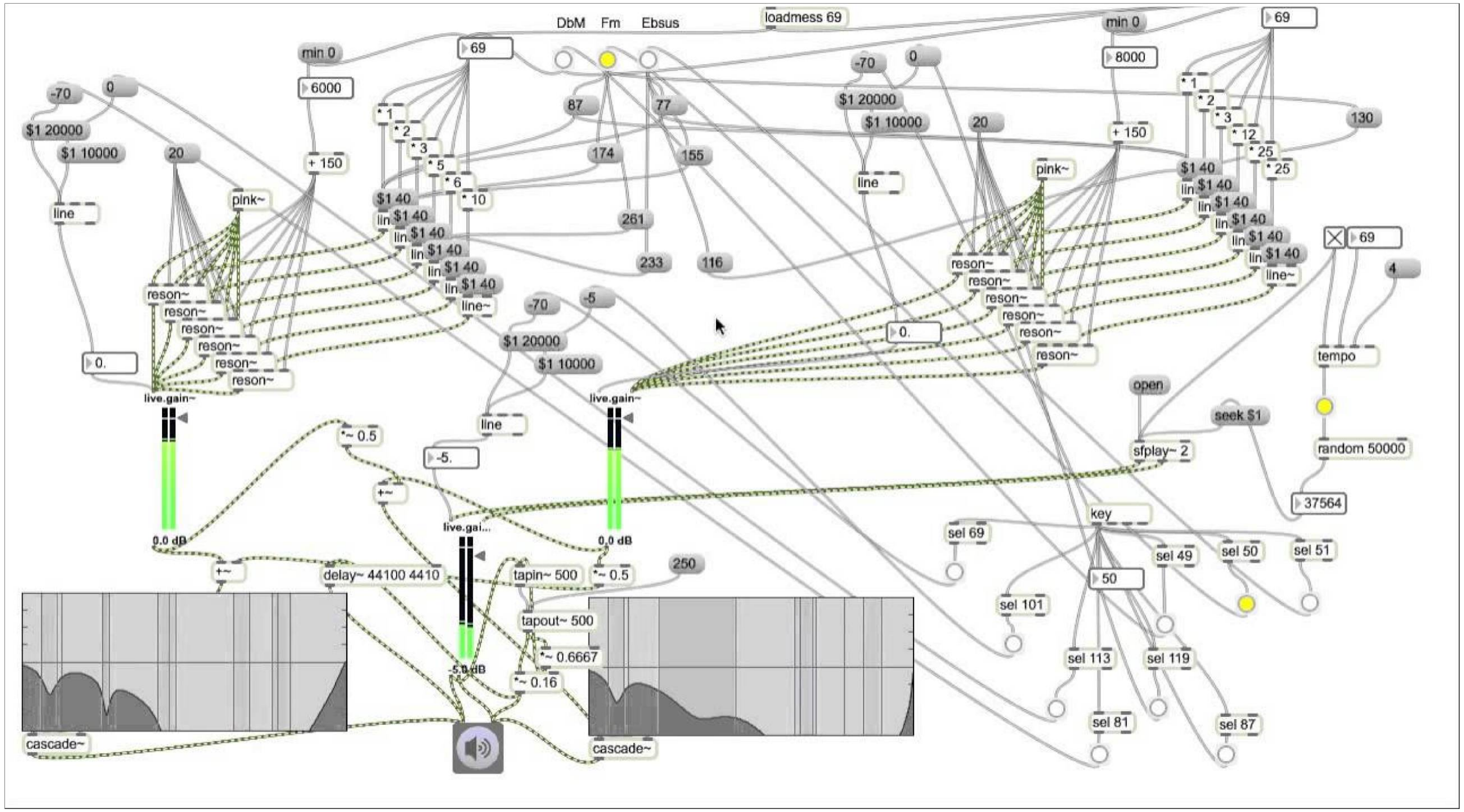
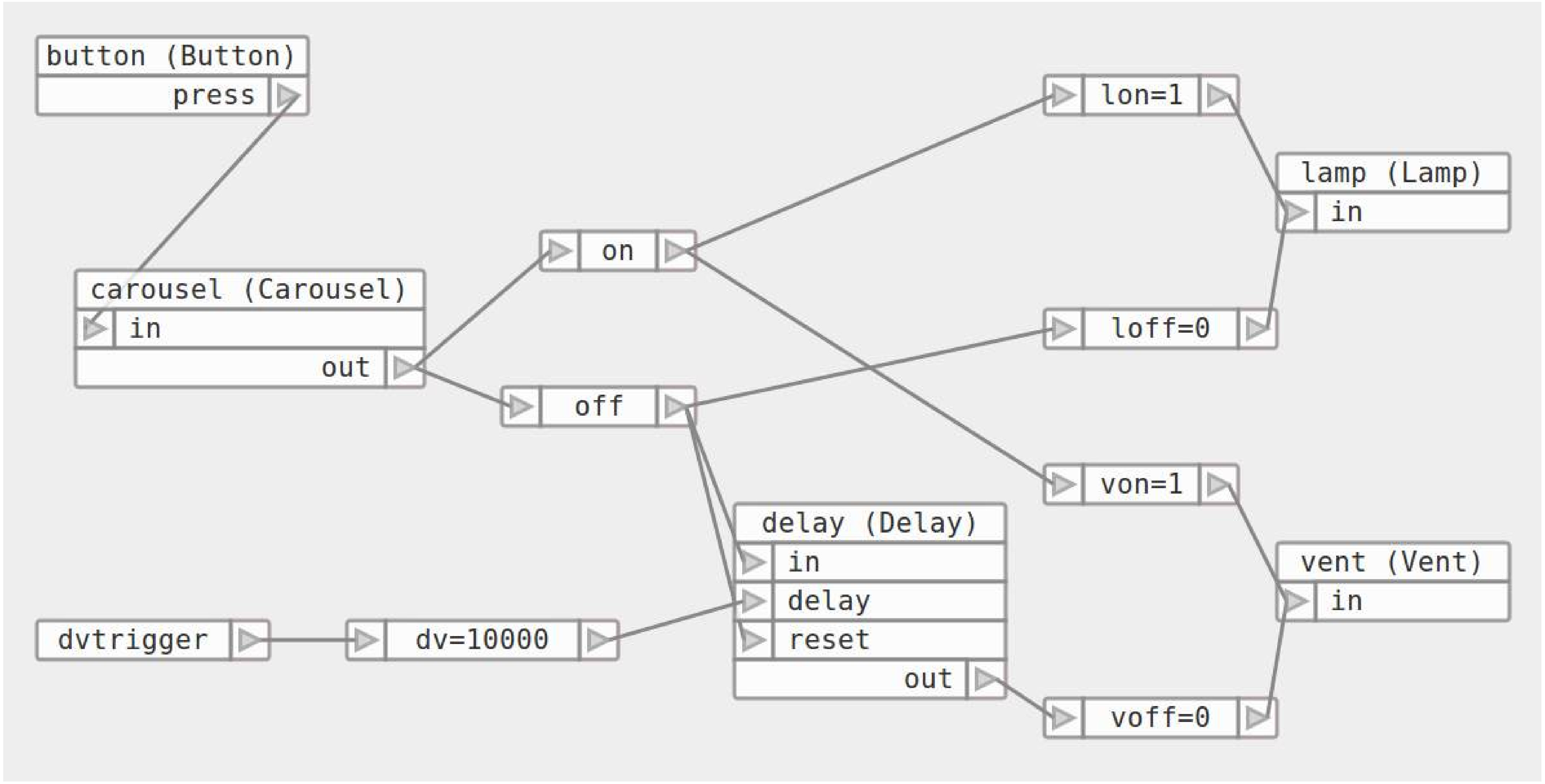
# Transparency

- Automatic documentation of the application
- Well-separated layers



# THE END



My favourite application. Can you find the bug?