a traffic analysis tool

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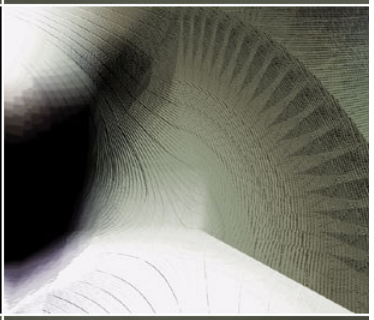
ESUG 2005



project background

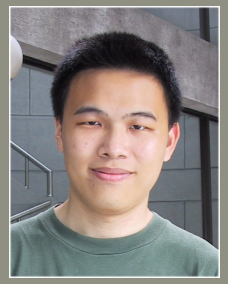
Maseeh College of Computer Science

Portland State University, Oregon, USA

Infopipes Research Project


Black


Walpole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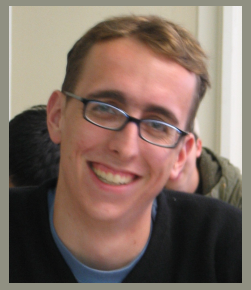
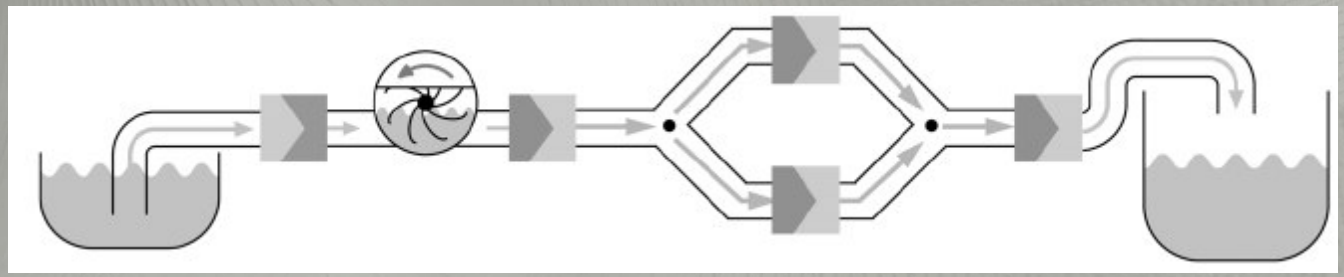

Murphy-Hill

Group moved from OGI to Portland State within the last year

infopipes project

- **Infopipes:**
  - **An abstraction for data-streaming**
  - **About data flow, not control flow**
  - **Like household water pipes**



Black02

- **Reusable components in streaming applications**

a simple infopipe

Encoder

```
->> anInfopipe
    downstream := anInfopipe

push: anItem
    downstream push: (anItem encode)
```

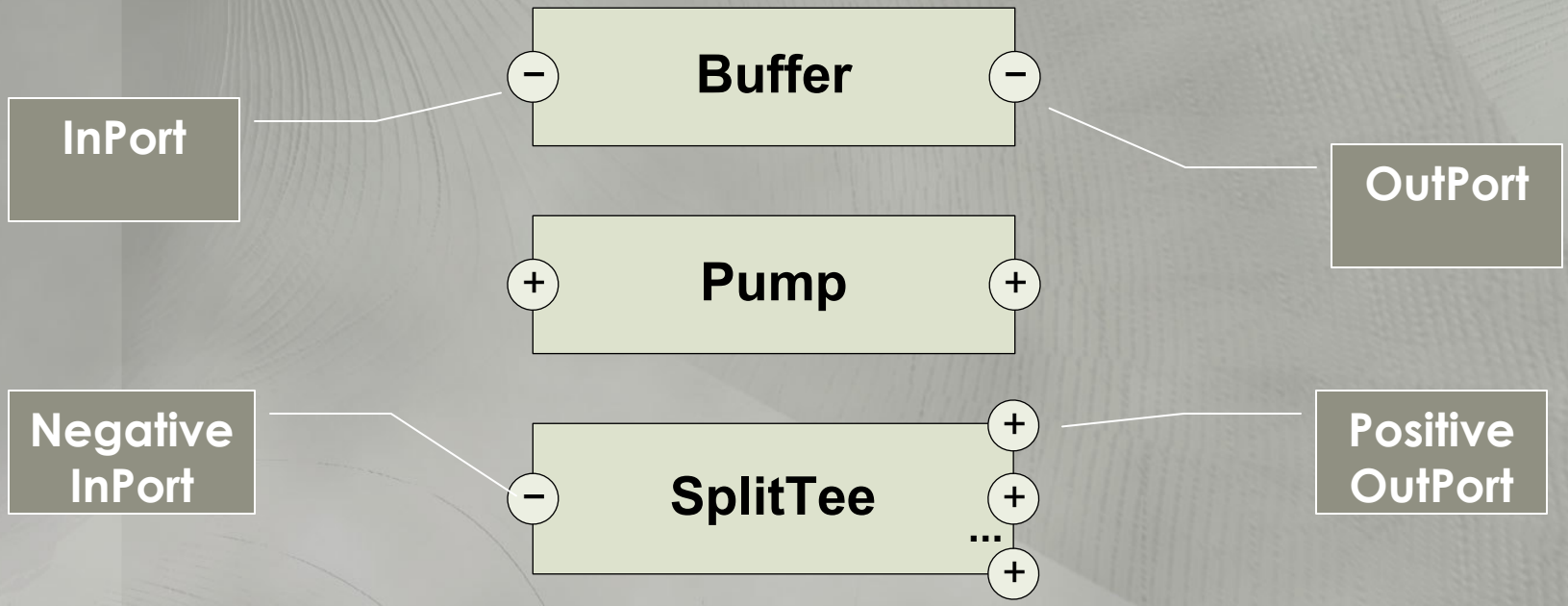
Use:

```
(Source new) ->>
    (pump := Pump new) ->>
    (Encoder new) ->>
    (Sink new).

pump strokeEveryMilliseconds: 10
```

ports and polarity

- Infopipes connect together with "Ports" (*In*Ports and *Out*Ports)
- Ports have "polarity," where control flow initiates from



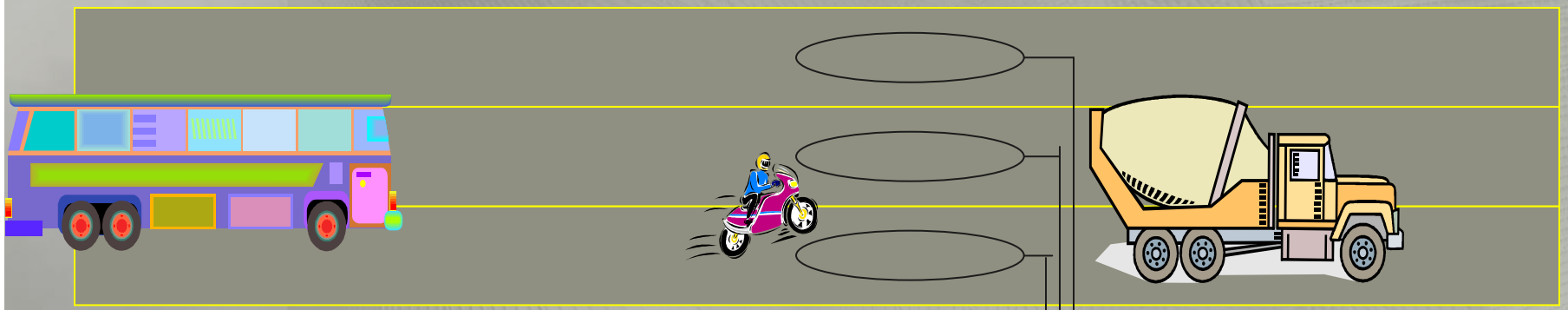
traffic analysis

- **Automobile traffic – a good fit!**
- **Traffic data is a continuous stream that can be analyzed for current traffic conditions**
- **A known problem in traffic analysis is *measuring truck volume***

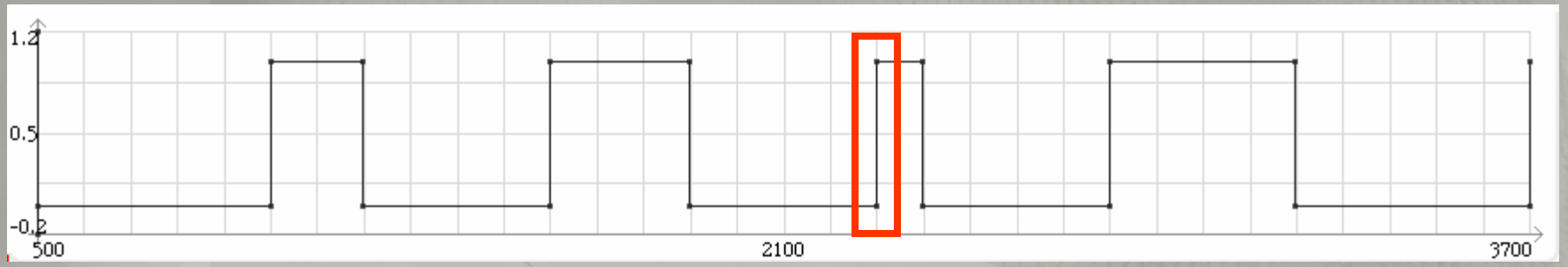
typical traffic hardware

why measuring truck volume is hard

- **Existing roadway hardware is limited**

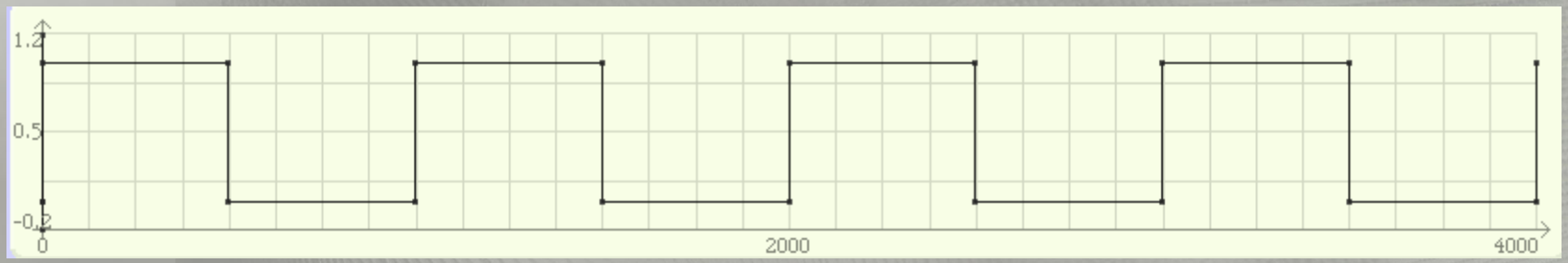


2 Trucks, 2 Cars



why measuring truck volume is hard (cont.)

Now, how many trucks here?



- **4 trucks, if traffic is moving at the same speed as before**
- **4 cars, if traffic is moving slower than before**
- **Or any combination of cars and trucks, if velocity changes through the sample period!**
- **So can you determine how many trucks have passed using this hardware?**

a method of counting trucks

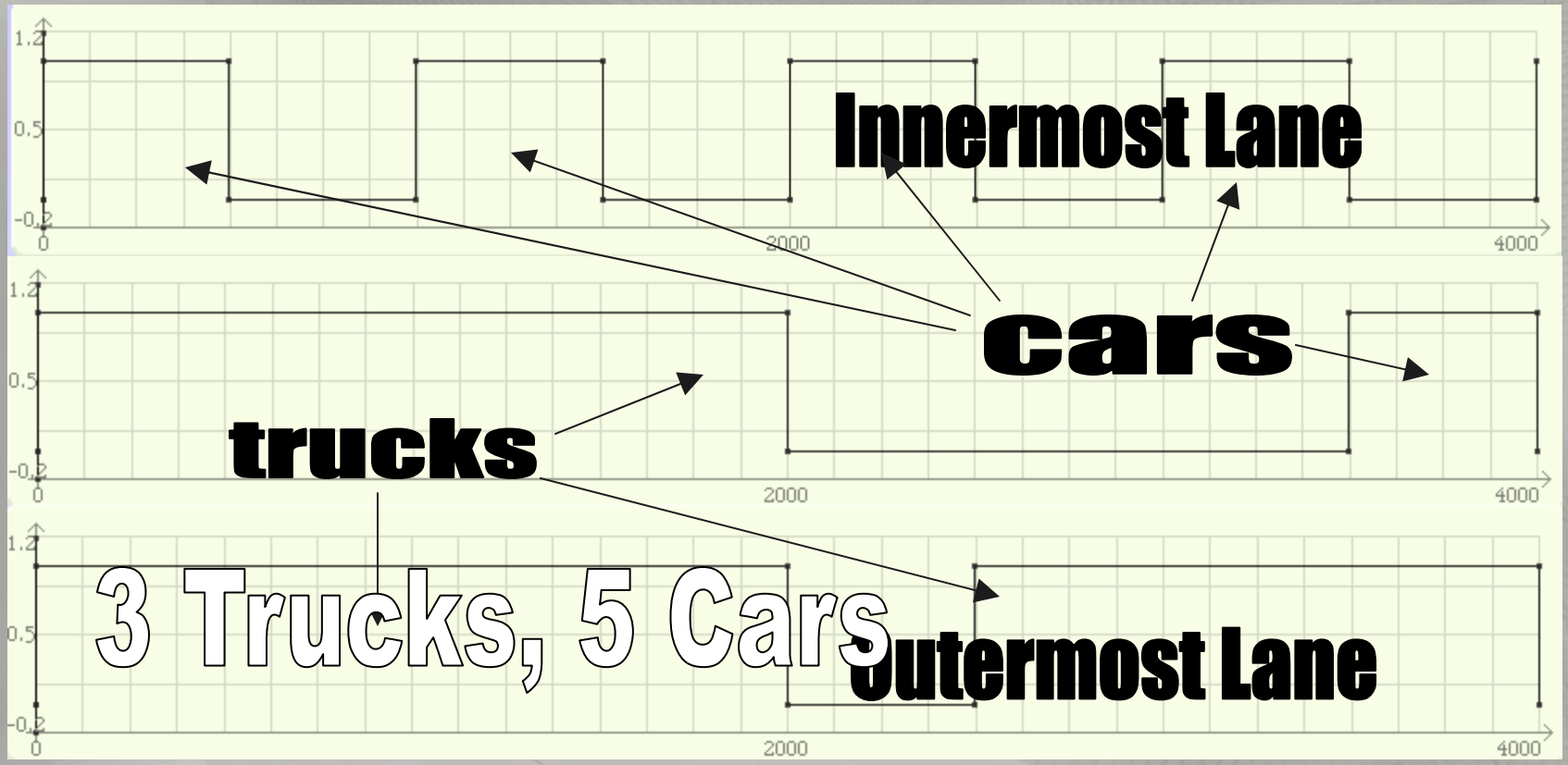
- **Kwon and colleagues suggested a method of counting trucks based on two simple observations:**
  1. **Traffic in the innermost lane is often truck-free**
  2. **Velocity in adjacent lanes are correlated over time**

for example…


GEORGE BRAZIL
Plumbing·Heating
Air Conditioning
24 HRS A DAY
TIP
TRANSPORT INTERNATIONAL POOL
DODGE
DO NOT PASS

so reconsider the problem

Now, how many trucks here?



implementation

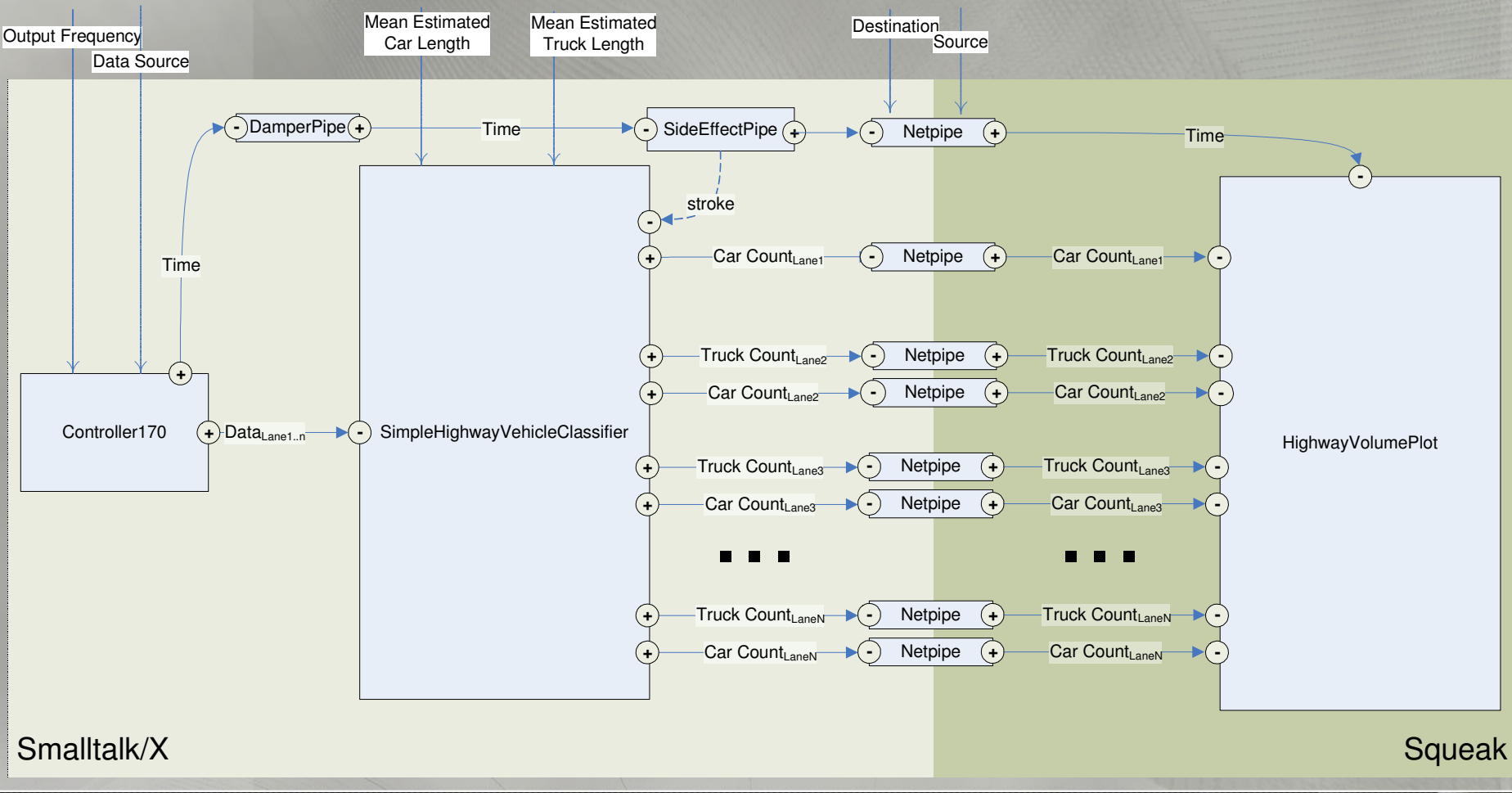
- We implemented this single loop truck volume algorithm
- We decided to use Smalltalk/X after ESUG 2004
  - Some Infopipes can benefit from in-lined C code
  - Simple tests show ST/X is faster than Squeak

implementation (cont)

- **Implementation consists of a variety of connected Infopipes**
  - **Used preexisting, general-purpose Infopipes (buffers, pumps, tees…)**
  - **Reused preexisting, traffic-specific Infopipes**
  - **Created new, traffic-specific Infopipes**
- **We eventually used Squeak in order to visualize the results**

implementation (cont)

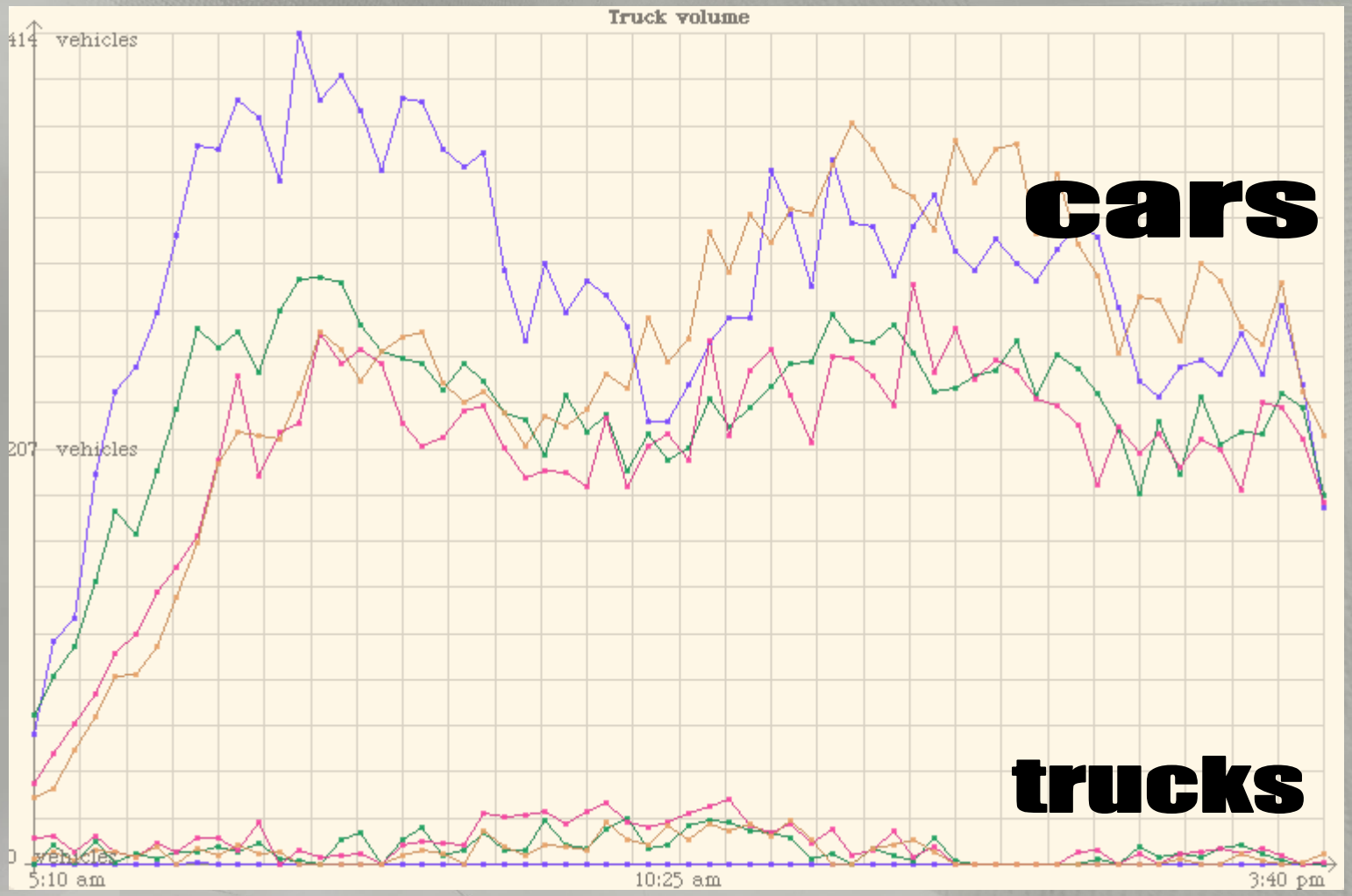
Top-level view:



implementation (cont)

- Uses about 50 classes
- An instance that analyzes 5 lanes encompasses more than 100 Infopipes
- Different pieces run at different rates, in separate threads, processes, or machines
- We believe it is representative of a modern streaming application

results


Truck volume
414 vehicles
207 vehicles
0 vehicles
5:10 am
10:25 am
3:40 pm
cars
trucks

reflections on smalltalk/x

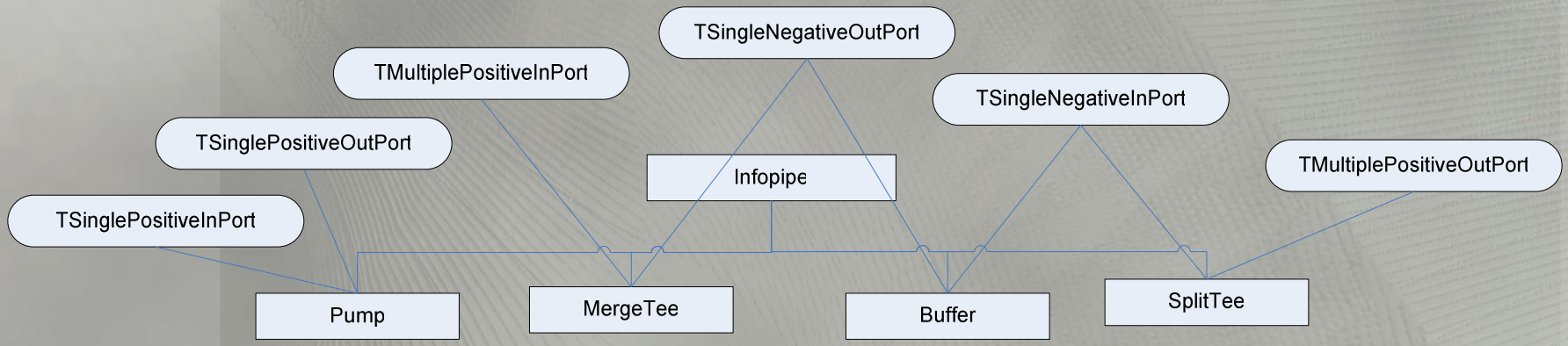
- Preferred browser to Squeak's
- Mostly compatible with Squeak (added ≈ 2 compatibility methods)
- Buggy at times
  - After an image crash, the VM sometimes overwrites the old image
  - My changes file is somehow inconsistent and missing code
- Some desirable features missing
  - Image not portable
  - Usability issues

working with st/x and squeak

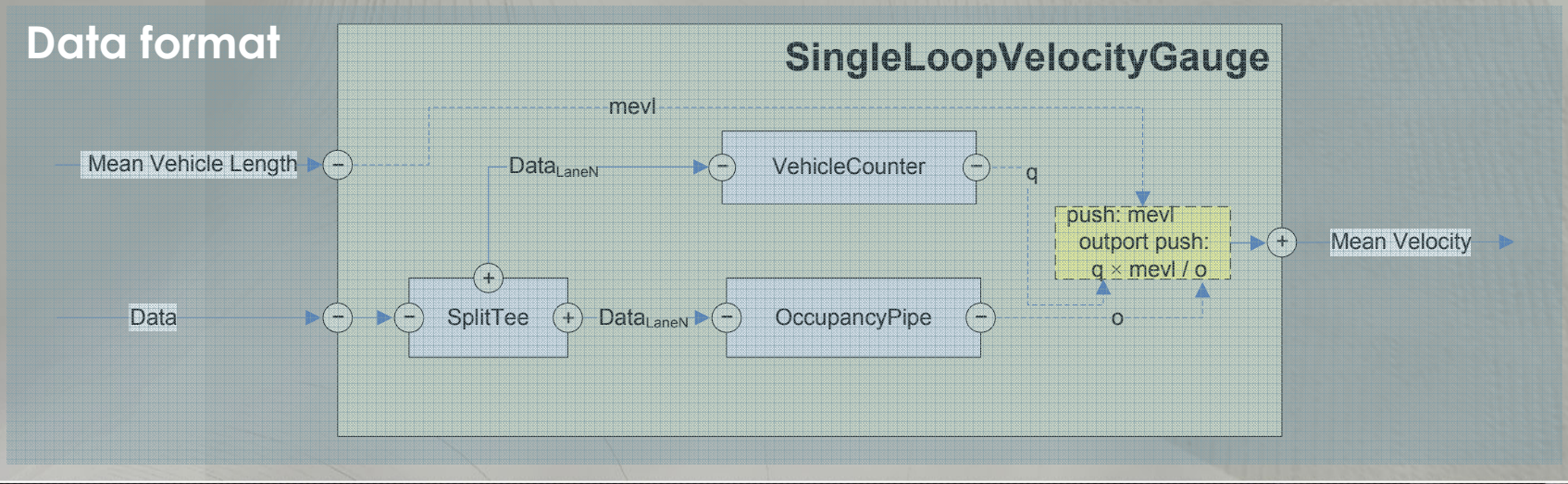
- Kept 4 changesets
  - ST/X only:
    - compatibility.cs
    - applicationCore.cs
  - Squeak only:
    - graphical.cs
  - Shared
    - commonInfopipes.cs
- When wrapped (in Netpipe), differences in sockets become a non-issue

language extensions wish list

- I wish I had traits



- Could have used classboxes



future work

- DirectFlow – a language for configuring pipelines
- Use algorithm with Portland's live, streaming data
- Use Infopipes created here in different traffic applications
- Compare Infopipe vs. non-Infopipe implementations

conclusion

- Infopipes encourage structuring streaming applications in good OO style
- Traffic applications lend themselves well to Infopipes
- Writing an application across Squeak and Smalltalk/X was relatively painless, although Smalltalk/X currently has shortcomings

references and links

- Kwon, J., Varaiya, P. and Skabardonis, A. (2003) "Estimation of Truck Traffic Volume from Single Loop Detector Outputs Using Lane-to-lane Speed Correlation," Presented at TRB 2003 and Forthcoming in *Transportation Research Record*.
- "Infopipes: An Abstraction for Multimedia Streaming," Andrew Black, Rainer Koster, Jie Huang, Jonathan Walpole, and Calton Pu, *Multimedia Systems (special issue on Multimedia Middleware), 8(5), pp. 406-419, ACM / Springer-Verlag, 2002.*
- "Writing Reusable Infopipes Using DirectFlow," Chuan-kai Lin. *ECOOP. 2005.*
- Google: Infopipes