

# Arbitrary Resolution Graphical Applications in SAGE

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# Today

Clustered Tiled Displays

- CGLX, SAGE

Static vs Dynamic Content

Porting applications

- issues: resolution, interaction
- potential solutions, workarounds

New Solution

- example (genome browser)

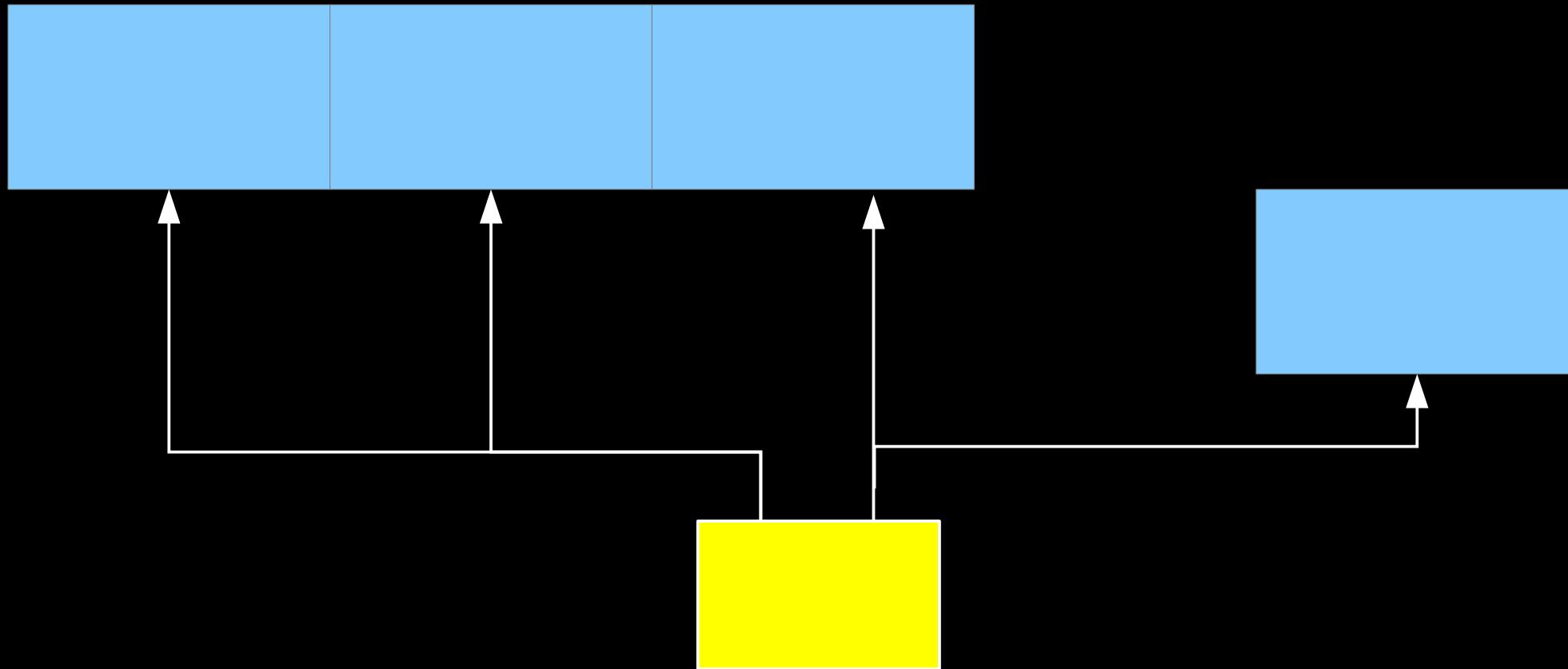
Summary

# Clustered Tiled Display (@EVL)



# Simple tiled display

single desktop across multiple display outputs from a single machine  
e.g. Access Grid room node



# Simple tiled display

## Limitations:

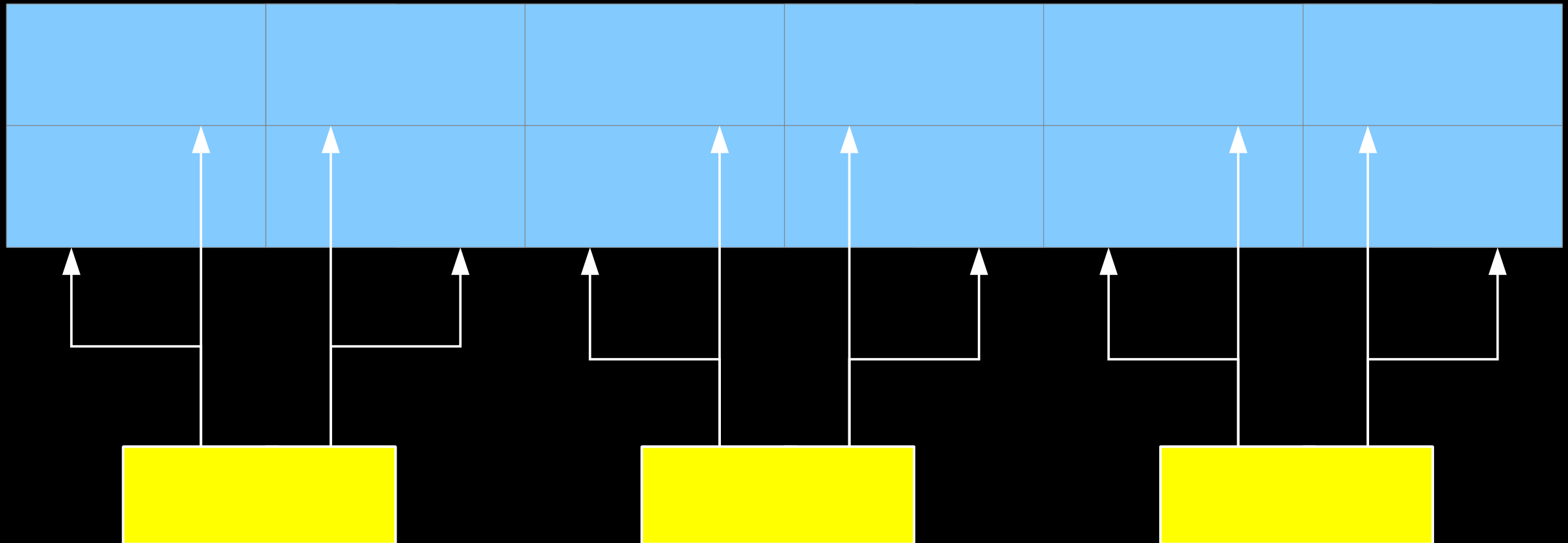
- number of outputs per graphics card
- number of available slots for graphics cards

## Solution:

- use multiple machines  
i.e. clustered tiled display

# Clustered tiled display

- multiple display outputs from multiple machines



# High resolution and/or multiple content



# CGLX, SAGE

CGLX (Cross platform Clustered Graphics Library)

- renders locally, directly to display (how to show remotely?)
- single GLUT-like application

SAGE (Scalable Adaptive Graphics Environment)

- renders anywhere, streams pixels via network
- multiple simultaneous applications  
i.e. (very) basic window management

# Images vs. Applications in SAGE

Size ( $\Rightarrow$  bandwidth)

- doesn't really matter for static images

Interaction

- no interaction with images

Conversely ...

# Displaying applications in SAGE

## Screen or window streaming

- *VNCViewer, dreamer, qshare, decklinkcapture*

## Intercept OpenGL calls

- `LD_PRELOAD=/path/to/libmyGL.so`

## Modify source code to use native streaming

- write display pixels to arbitrary size buffer, then call *sage.swapBuffer()*

# What if no source code?

Q. How to run application at greater than screen size?

A. X Virtual Frame Buffer (Xvfb)

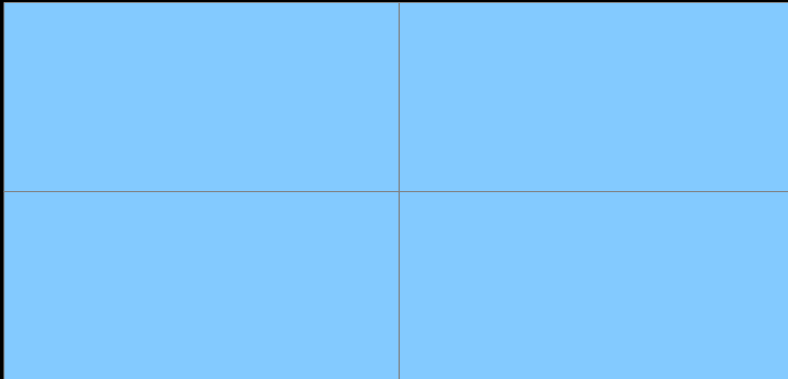
# Application streaming requirements

1920x1080



(YUV)  $1920 * 1080 * 16\text{bpp} * 25\text{fps} = \sim 830 \text{ Mbps}$

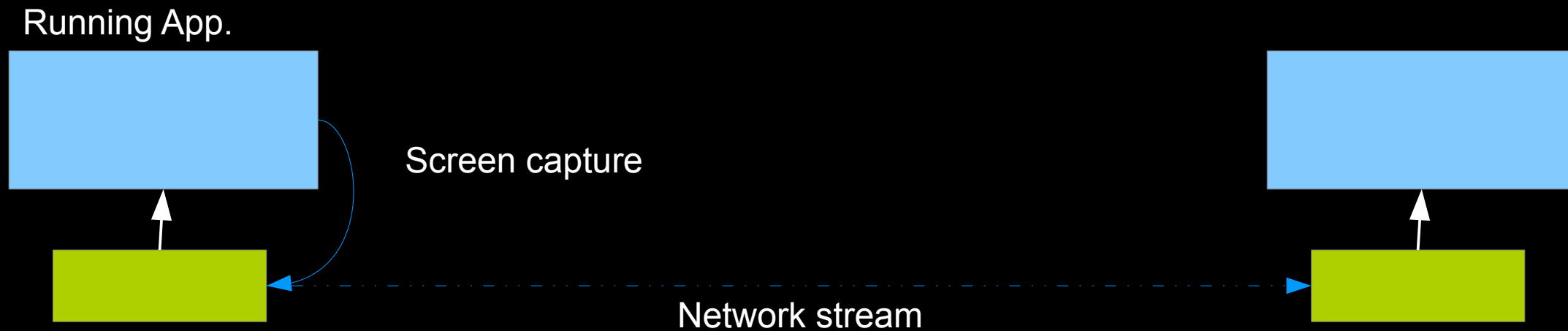
(RGB)  $1920 * 1080 * 24\text{bpp} * 25\text{fps} = \sim 1,250 \text{ Mbps}$



$3840 * 2160 * 24\text{bpp} * 25\text{fps} = \sim 5\text{Gbps}$

# Interaction problem

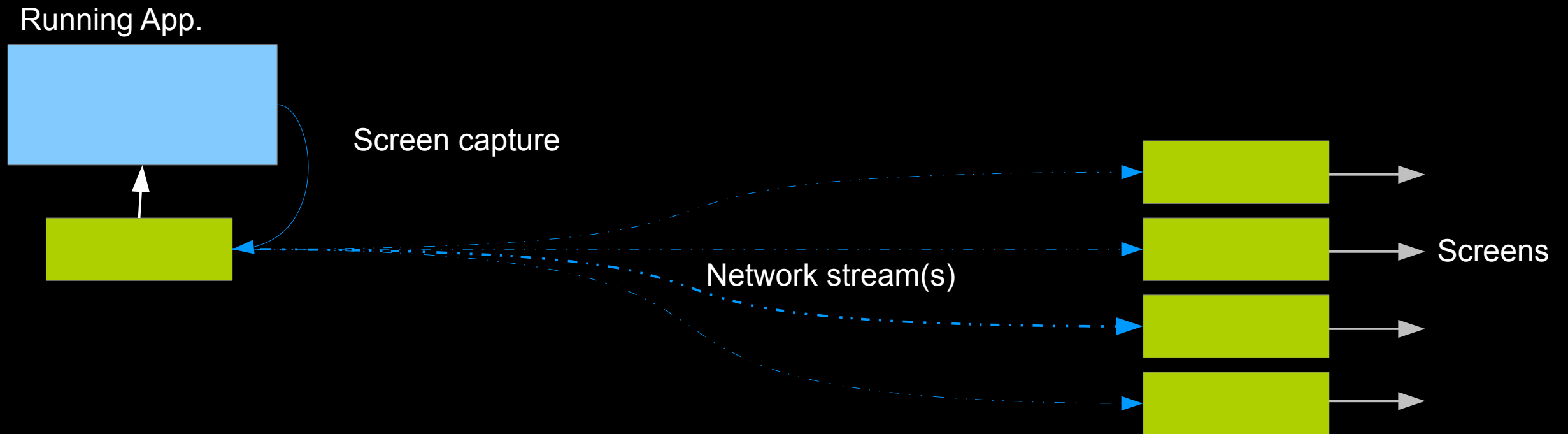
Streaming display contents is easy



What about keyboard/mouse events?

# Interaction problem

Streaming display contents is easy



What about keyboard/mouse events?

# Interaction problem

Streaming Xvfb contents is easy

Running App.  
in large Xvfb



Network stream(s)



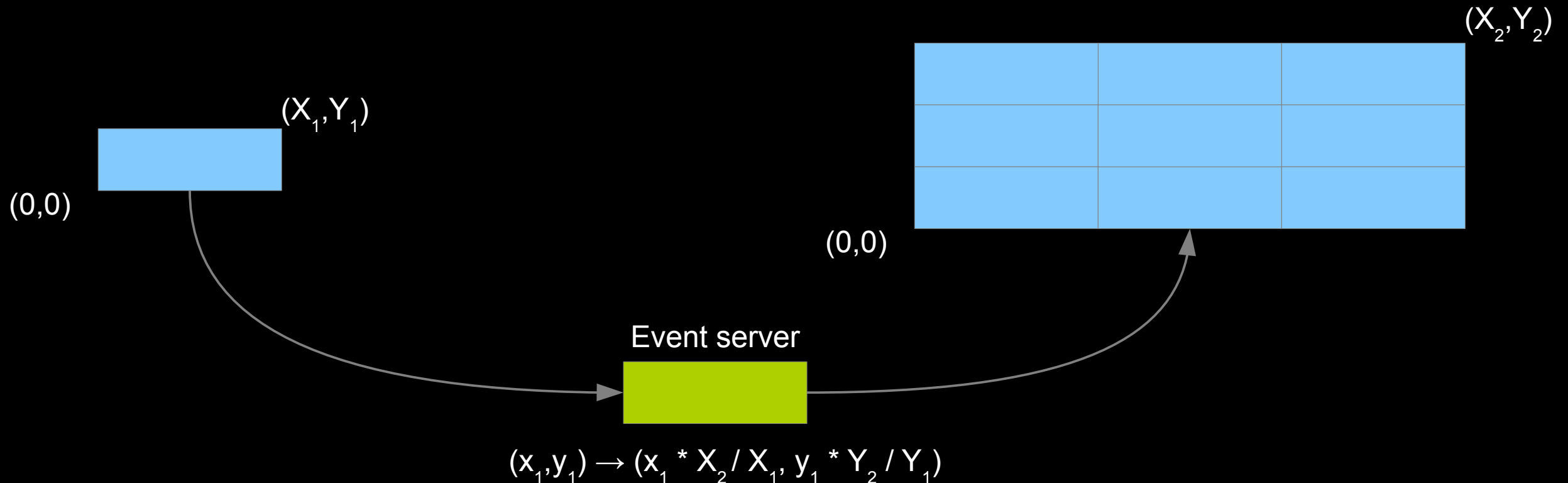
Screens

What about keyboard/mouse events?

# Shared control of applications - 1

Dedicated event server (Questnet 2010)

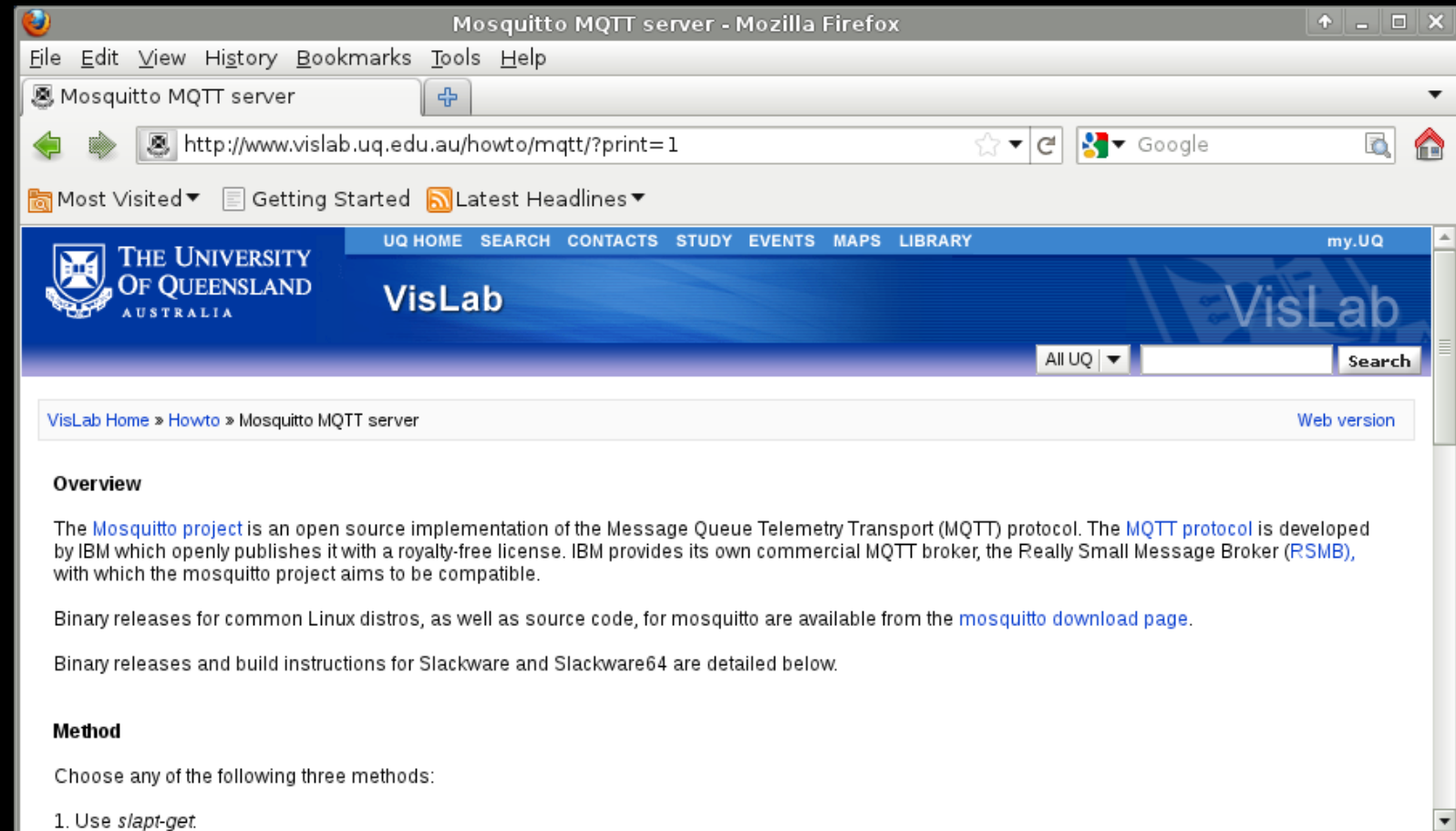
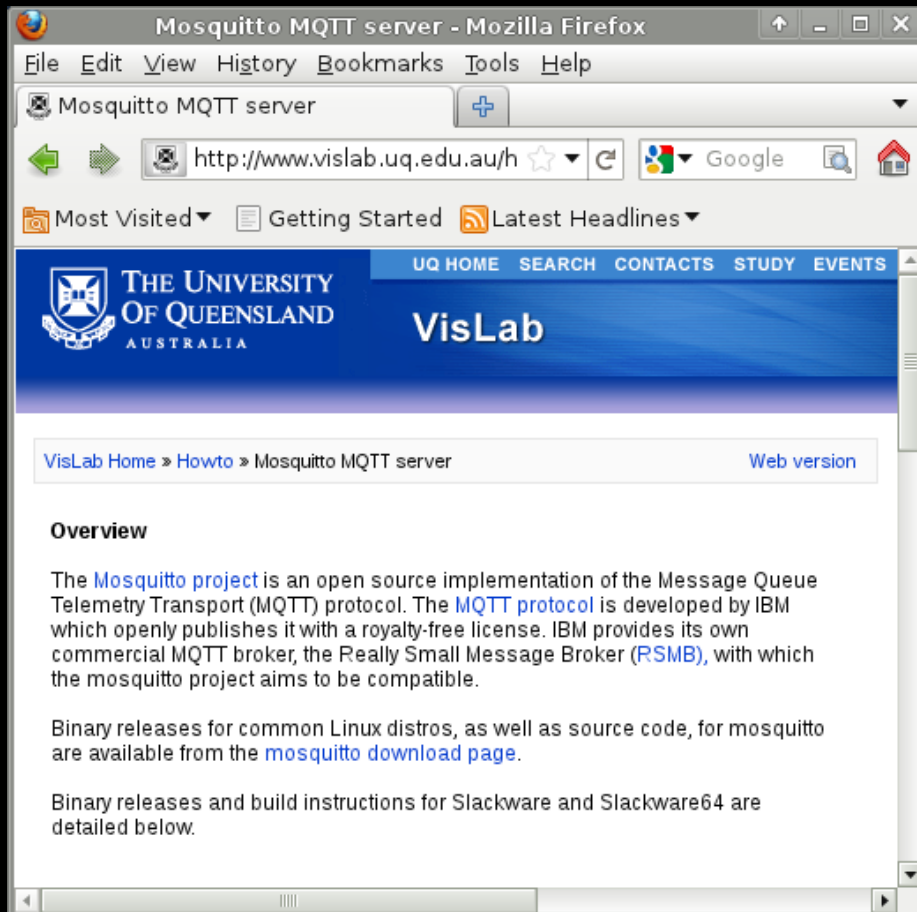
- multiple app instances share events via server



# Direct mapping issue

Simple position mapping is quite limited

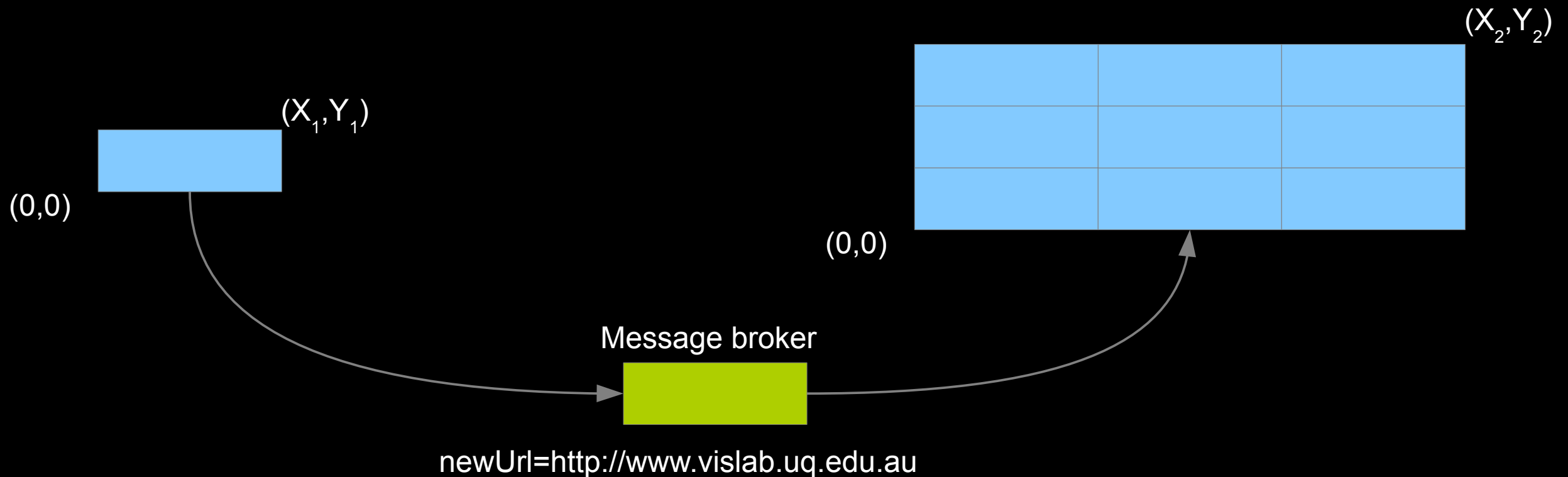
- layout may vary with display size e.g. web browser



# Shared control of applications - 2

Generalised message broker (mosquitto.org, MQTT Protocol)

- multiple app instances share information via broker



# So far ...

- how to run app at bigger than local screen size?
- want general solution  
i.e. assume no access to application source code
- Xvfb  
stream large Xvfb containing any application  
but  
no events i.e. no interaction with application

# Solution

SAGE event loop already provides mouse position coordinates and simple events e.g. “button down”

Use collected events to synthesise equivalent events inside an Xvfb using Xtest extension

We provide *screamer* (SCReen strEAMER) to stream Xvfb and synthesise events.

# Example: Genome Browser

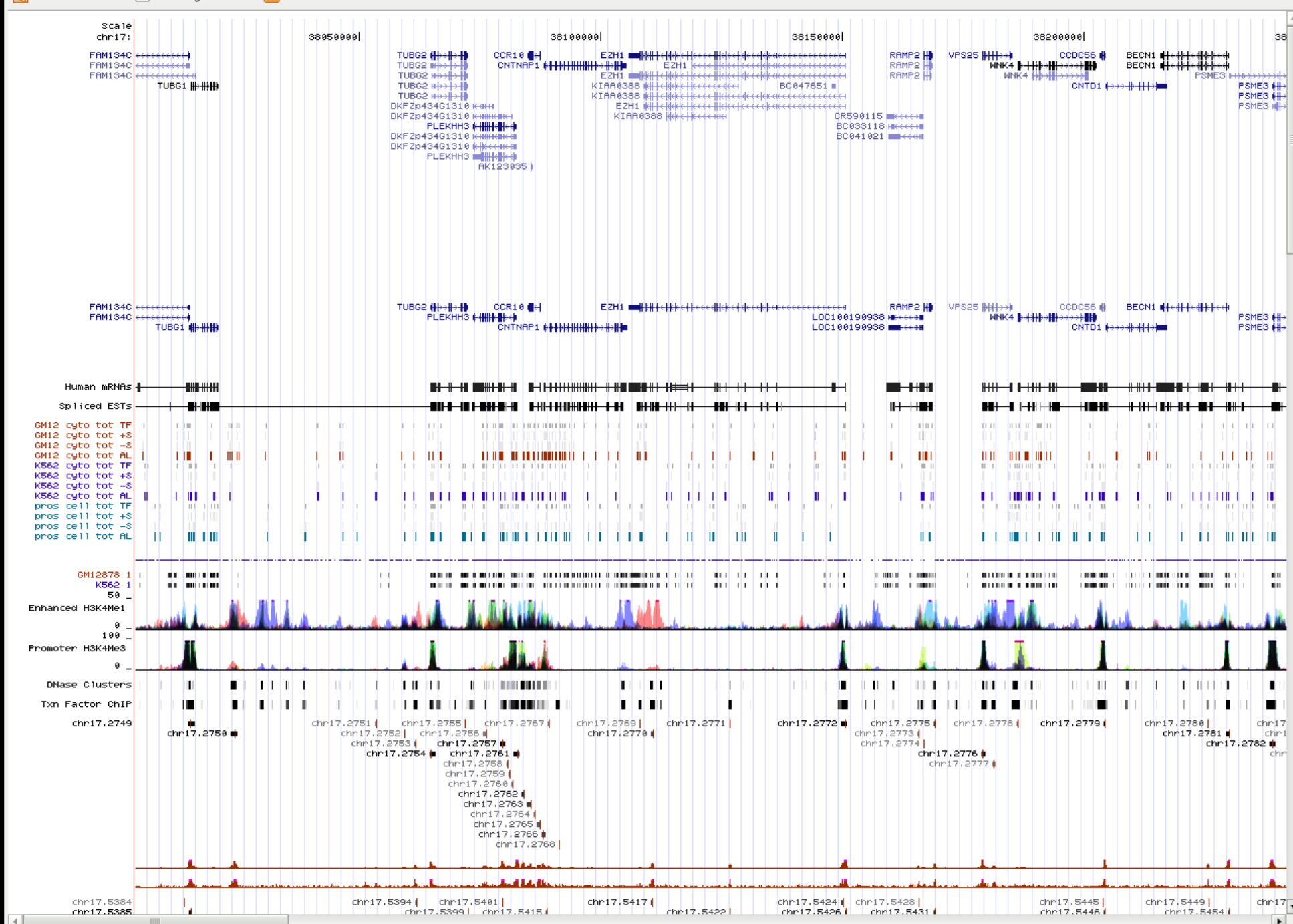
Practitioner accesses database via standard web browser with returned output up to 5000 pixels wide

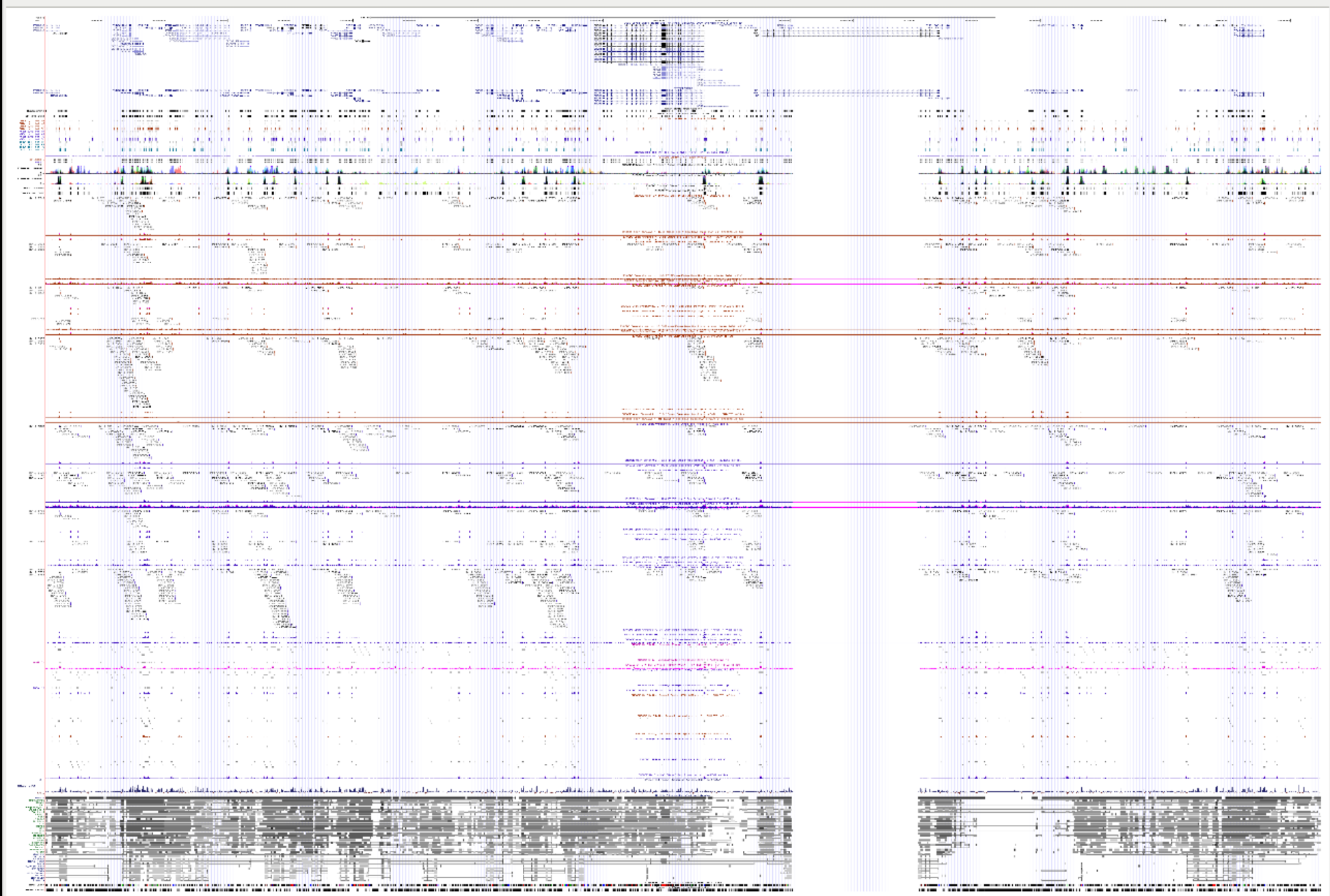
Problem:

- view only partial result at full resolution

OR

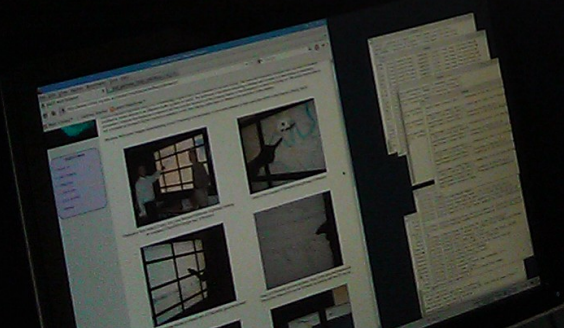
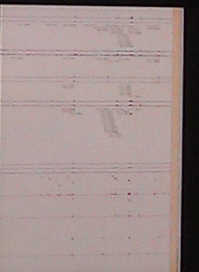
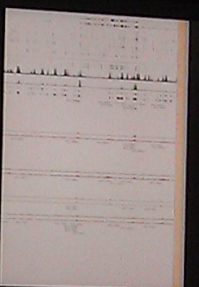
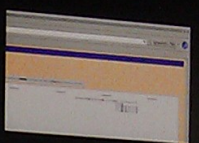
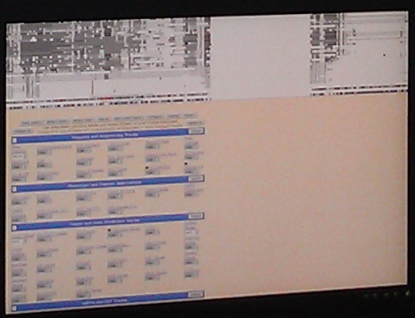
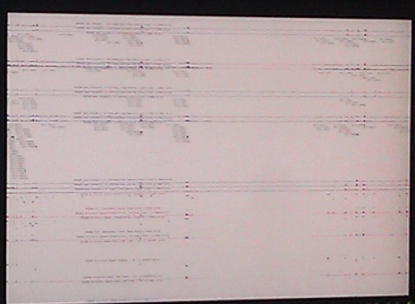
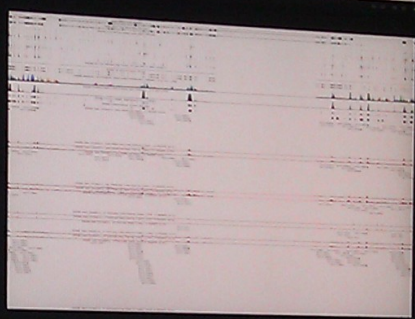
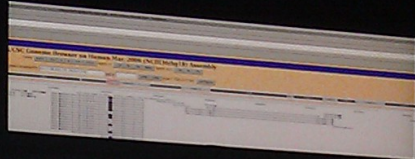
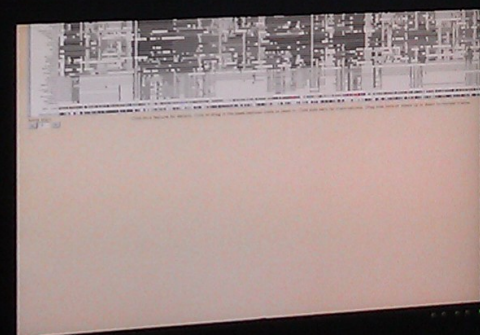
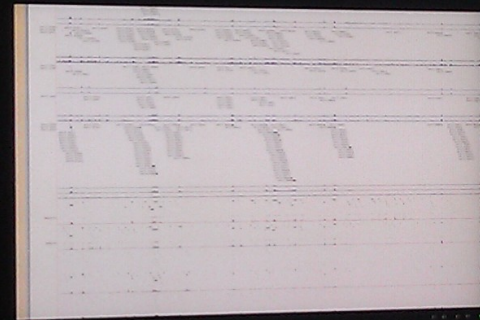
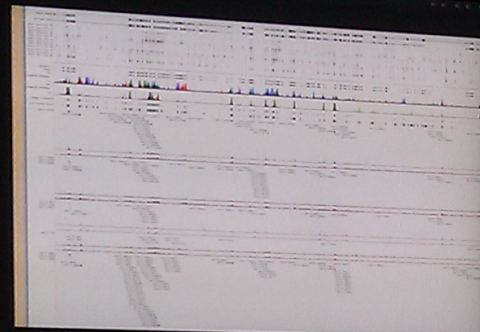
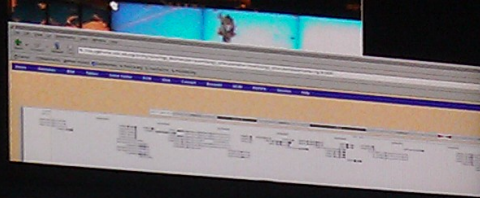
- view whole result – meaningless on normal screen





# Commands

- > Xvfb :1 -screen 0 5100x3600x24
- > fvwm2 -display :1 (optional)
- > seamonkey --display=:1
- > screamer :1 -show\_original





6227 |

chr17.6238 |  
chr17.6239 |

chr17.6231 | chr17.6237 |  
chr17.6232 |  
chr17.6233 |  
chr17.6234 |  
chr17.6235 |

chr17.6238 | chr17.6243 |  
chr17.6239 | chr17.6250 |  
chr17.6240 | chr17.6252 |  
chr17.6242 |  
chr17.6245 |  
chr17.6246 |  
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chr17.6253 |

chr17.1823 |  
chr17.1824 |

chr17.1825 | chr17.1826 |  
chr17.1827 | chr17.1828 | chr17.1829 |

chr17.1265 |

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# Issues

Recall:

$$\begin{aligned}\text{bandwidth} &= w * h * \text{bpp} * \text{fps} \\ &= 5100 * 3600 * 24 * 25 \\ &= 11\text{Gb/s}\end{aligned}$$

$$\begin{aligned}\text{fps} &= \text{bandwidth} / (w * h * \text{bpp}) \\ &= 1\text{GHz} / (5100 * 3600 * 24) \\ &= \sim 2.2\text{fps}\end{aligned}$$

# Summary

SAGE can return basic mouse events from application

Xvfb enables arbitrary sized application execution

Xtest enables event synthesis in Xvfb

New *screamer* application

- deals just with Xvfb, not apps running inside Xvfb
- collects mouse events from SAGE
- synthesises X events in Xvfb with Xtest
- streams Xvfb to SAGE tiled display

Bandwidth intensive (depending on Xvfb size)