RandR 1.3

Transformation, Panning, Properties

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So far: RandR 1.2

- Interface to dynamically set and query
  - Monitor attachment
  - Displayed / known modes
  - Framebuffer size
  - Scanout areas (multiple)
- Lacking
  - Querying state involves output probing
  - Panning
  - Display in non-1:1 fashion
  - Output types (panel vs. external output)
- Framebuffer size limited to initial allocation

State of RandR 1.3

- To be released with Xserver 1.6
  - Features set, just bugfixing / validation now
    - randrproto 1.2.99.3 +
    - libXrandr 1.2.99.4 +
    - xrandr 1.2.99.4
    - Xserver 1.5.99.902

RandR 1.3 Additions

- Additions
  - Querying state without output probing
  - Multi-monitor panning
  - Display transformations
  - Standard properties (output and signal types), primary output definition
- Framebuffer size limitation not solvable with current XAA implementation

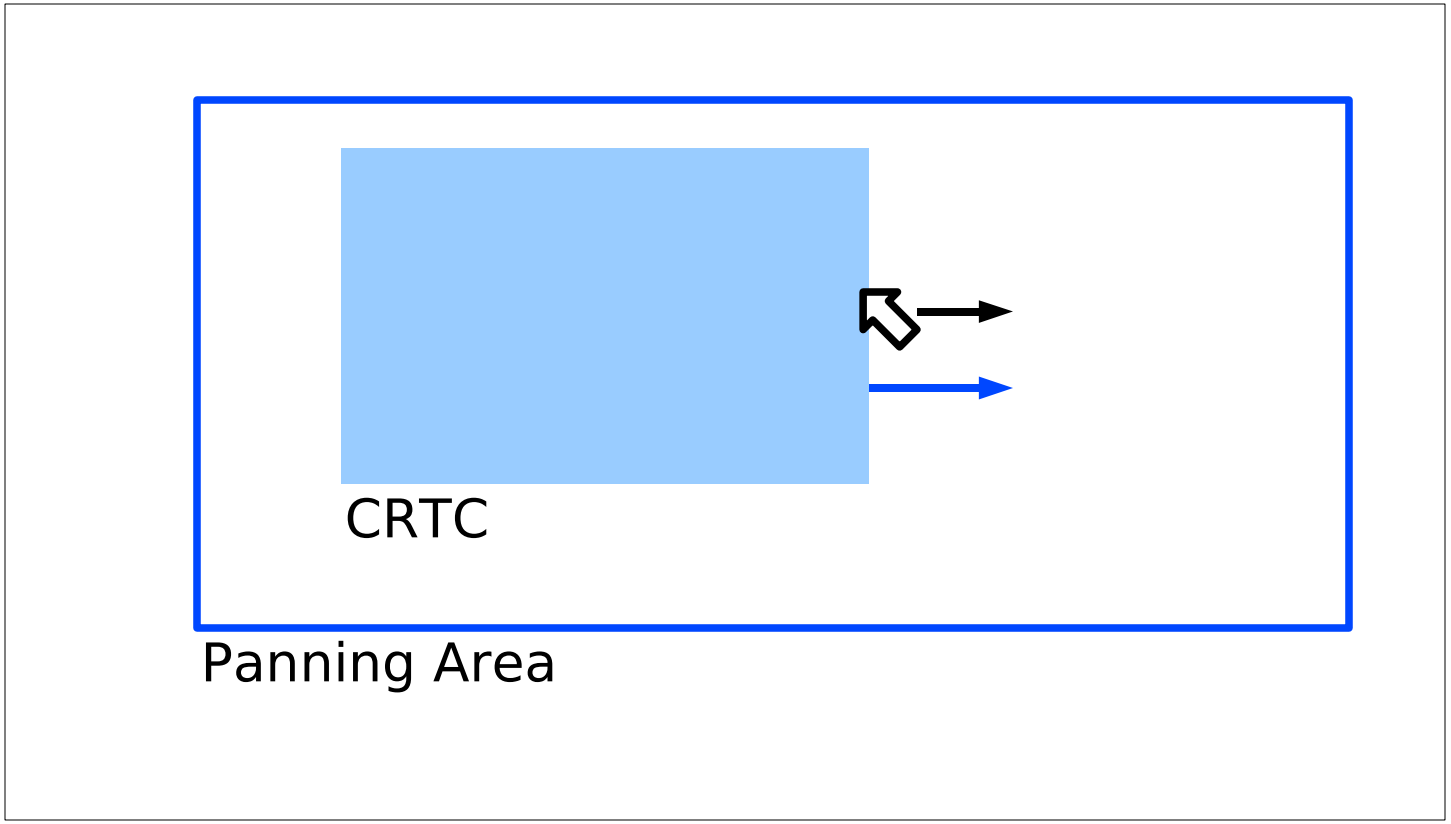
State Querying w/o Polling

- RRGetScreenResourcesCurrent
  - Equivalent to RRGetScreenResources
  - Just no polling
- Note: You won't get notified of new monitors with this one
- xrandr --output VGA --current

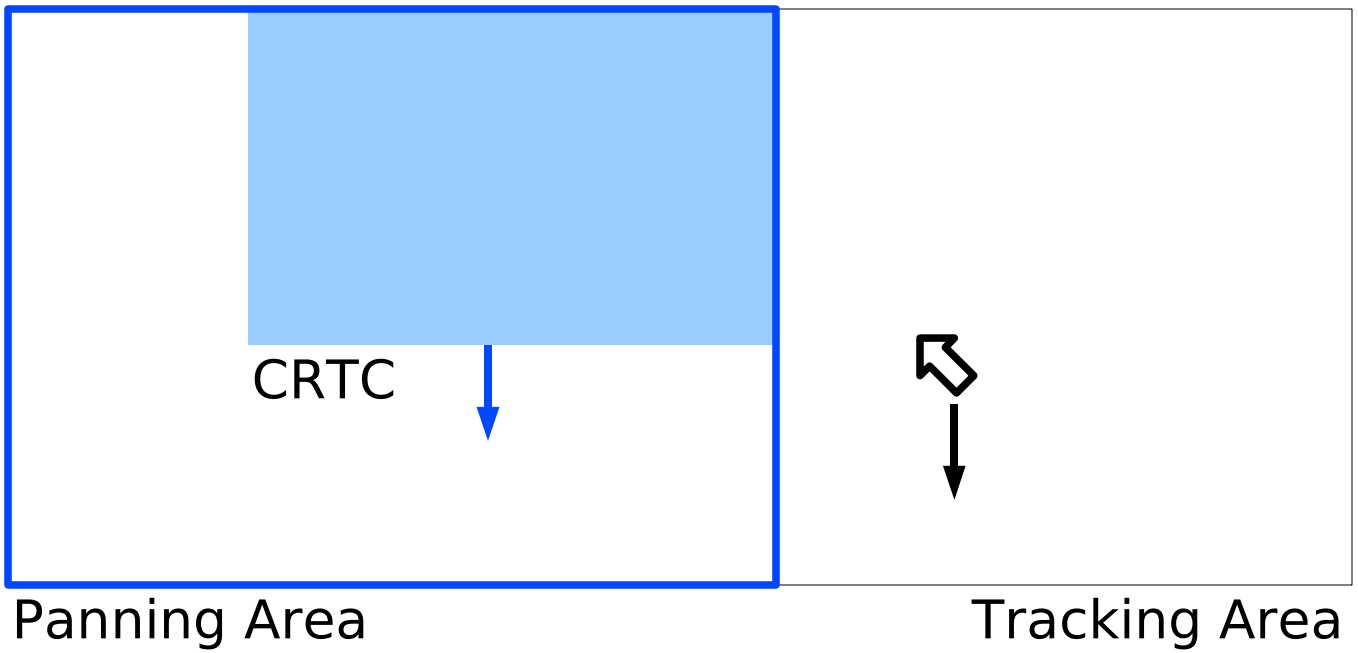
Panning

- Change viewport when mouse hits screen borders
  - Needs updated driver for seamless movement:
    xf86CrtcFuncsRec.set_origin()
  - Otherwise prepare(), mode_set(), commit() is called, which typically flickers
  - RRGetPanning, RRSetPanning
- xrandr –-panning <w>x<h>[+<x>+<y>
  [/<track:w>x<h>+<x>+<y>
  [/<border:l>/<t>/<r>/<b>]]]
  - e.g. xrandr –-output VGA –-panning 2000x1200+0+0/2000x1200+0+0/100/100/100/100
- Three parameter sets per panned output:
  - Panning area
  - Tracking area
  - Borders

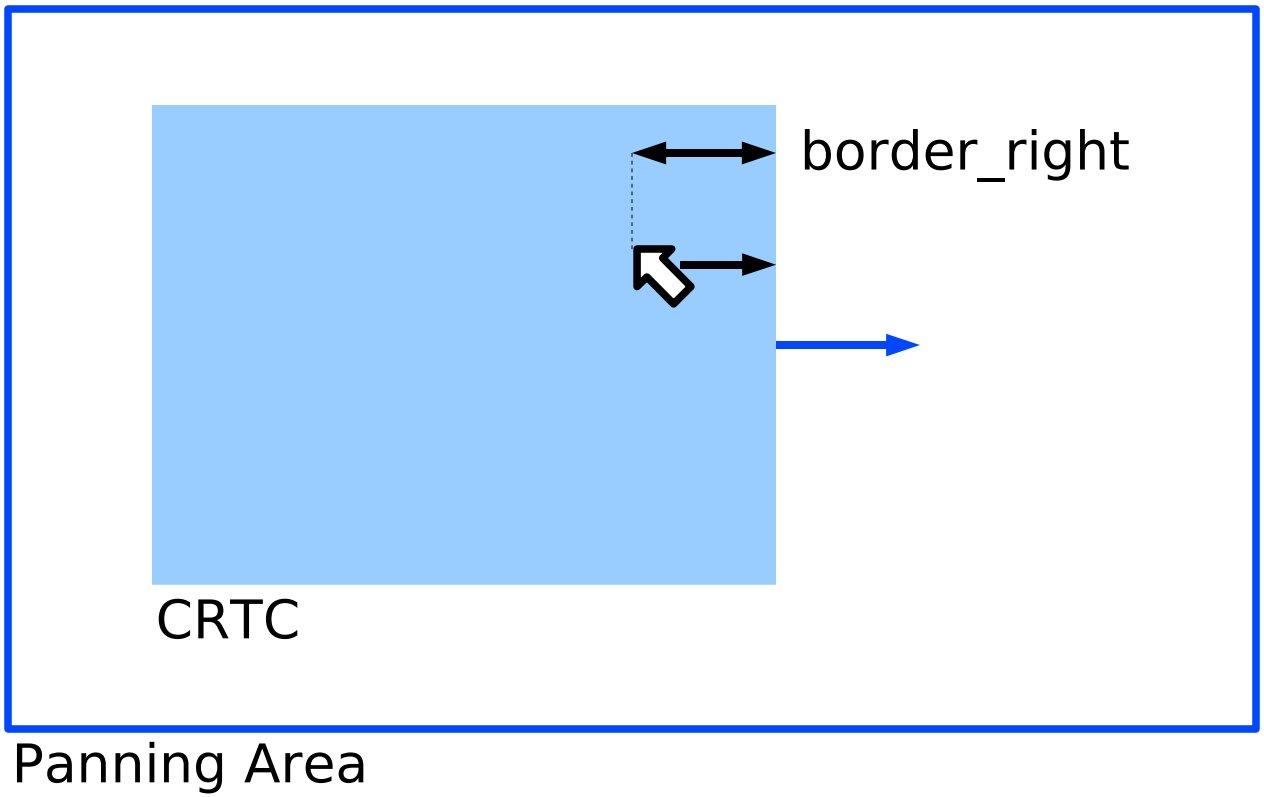
Panning: Panning Area



Panning: Tracking Area



Panning: Borders

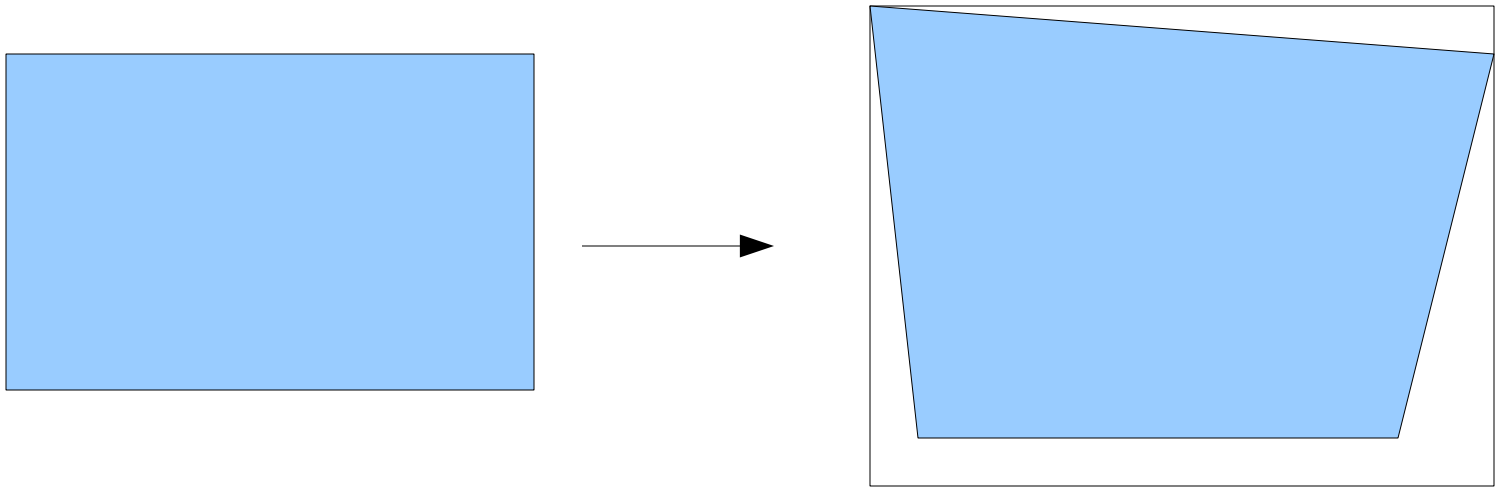


Panning: Unresolved

- RRGetCrtcInfo currently returns CRTC view.
  CRTC or Panning Area?
- Placement logic in xrandr.
  Again, CRTC or Panning Area driven?
- Dual head + panning could mean
  - Whole space pans when you get to the side of the virtual space
  - Each physical display pans separately
  - A combination of these two
- Looks like all three are possible to specify with borders – xrandr needs update, though
- Panning and transformations don't fit together

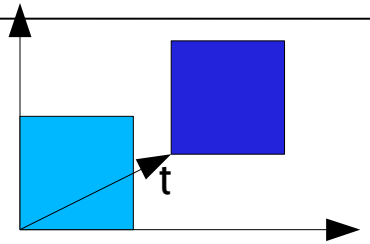
Display Transformations

- Perspective transformation of CRTC content
- Rotation, flipping, scaling, keystone correction
- Based on homogeneous coordinate transformation

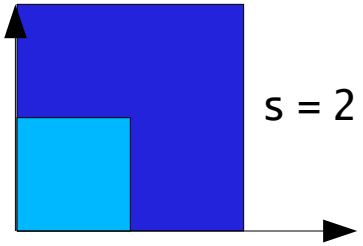


Transformations: Types

- Translation $\mathbf{v}' = \mathbf{v} + \mathbf{t}$ $\begin{pmatrix} v'_x \\ v'_y \end{pmatrix} = \begin{pmatrix} v_x + t_x \\ v_y + t_y \end{pmatrix}$

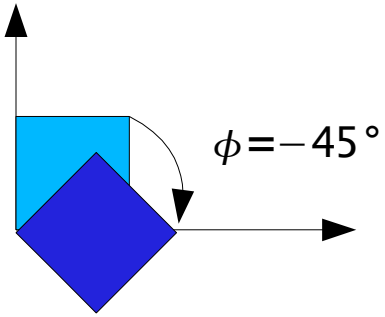


- Scaling $\mathbf{v}' = s \cdot \mathbf{v}$ $\begin{pmatrix} v'_x \\ v'_y \end{pmatrix} = \begin{pmatrix} s \cdot v_x \\ s \cdot v_y \end{pmatrix}$



- Rotation $\mathbf{v}' = \mathbf{R}(\phi) \cdot \mathbf{v}$ $\begin{pmatrix} v'_x \\ v'_y \end{pmatrix} = \begin{pmatrix} \cos\phi & -\sin\phi \\ \sin\phi & \cos\phi \end{pmatrix} \cdot \begin{pmatrix} v_x \\ v_y \end{pmatrix}$

- Projection $\mathbf{v}' = \mathbf{P}(\mathbf{v})$ $\begin{pmatrix} v'_x \\ v'_y \end{pmatrix} = \begin{pmatrix} v_x / w \\ v_y / w \end{pmatrix}$



Homogeneous Coordinates

- All transformations of previous slide:
  3 component matrix-vector multiplication

$$\mathbf{u} = \begin{pmatrix} u_x \\ u_y \end{pmatrix} \Leftrightarrow \mathbf{v} = \begin{pmatrix} v_x \\ v_y \\ v_w \end{pmatrix} = \begin{pmatrix} u_x \cdot w \\ u_y \cdot w \\ w \end{pmatrix}$$

$$\text{2D} \rightarrow \text{homogen:} \quad \mathbf{v} = \begin{pmatrix} x \\ y \\ 1 \end{pmatrix} \qquad \text{homogen} \rightarrow \text{2D:} \quad \mathbf{u} = \begin{pmatrix} x/w \\ y/w \end{pmatrix}$$

- Associative: Transformations can be aggregated:

$$\mathbf{b}=\mathbf{M}_1 \cdot \mathbf{a} \;,\; \mathbf{c}=\mathbf{M}_2 \cdot \mathbf{b} \Rightarrow \mathbf{c} = \mathbf{M}_2 \cdot (\mathbf{M}_1 \cdot \mathbf{a}) = (\mathbf{M}_2 \cdot \mathbf{M}_1) \cdot \mathbf{a} = \mathbf{M}_{21} \cdot \mathbf{a}$$

Homogeneous Transformations

- Translation $\mathbf{T}(\mathbf{t}) = \begin{pmatrix} 1 & 0 & t_x \\ 0 & 1 & t_y \\ 0 & 0 & 1 \end{pmatrix}$
- Scaling $\mathbf{S}(s) = \begin{pmatrix} s & 0 & 0 \\ 0 & s & 0 \\ 0 & 0 & 1 \end{pmatrix}$
- Rotation $\mathbf{R}(\phi) = \begin{pmatrix} \cos\phi & -\sin\phi & 0 \\ \sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{pmatrix}$
- Projection $\mathbf{P}(d) = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 1/d & 0 \end{pmatrix}$

Transformations in RandR1.3

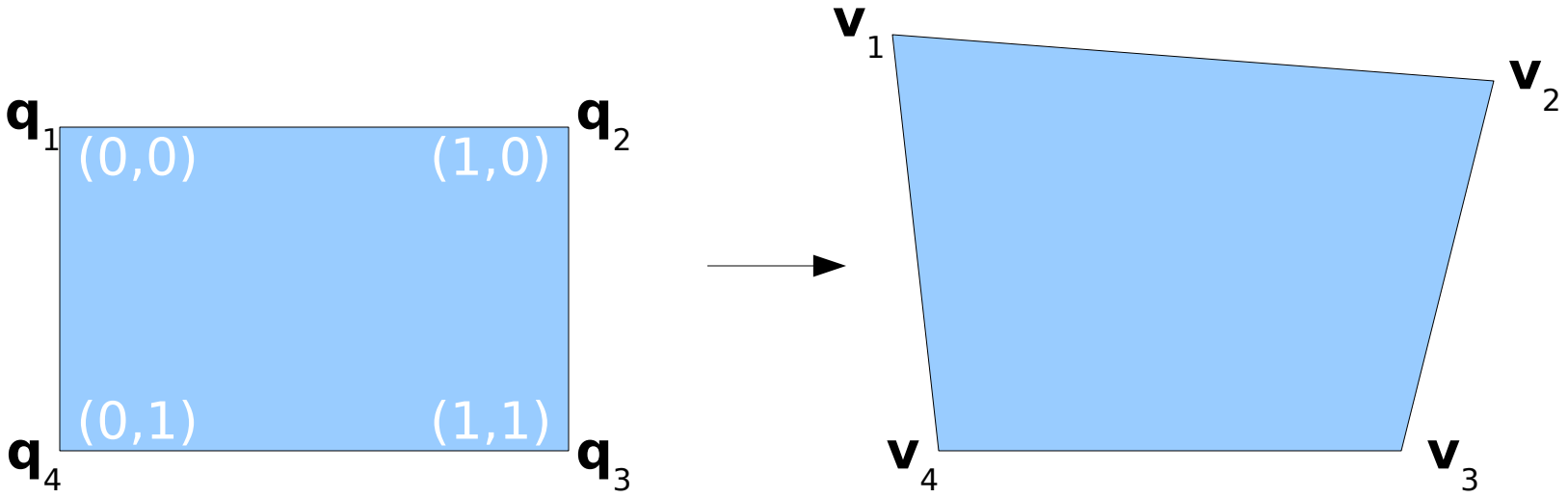
- RRSetCrtcTransform
- xrandr ––transform [9 floats]
  Specifies the transformation matrix, e.g.

  xrandr ––output PANEL
  ––transform 2,0,0,0,2,0,0,0,1

  scales image by a factor of 2 down
- Rotation and reflection multiplied to general transformation in the Xserver

Keystone Correction

- Example: “keystone.5c” in app/xrandr
- Basic idea: Transform vertices of unit quad
- Solve equation system to calculate **M**
- Need inverse transformation $\Rightarrow \mathbf{M}^{-1}$



Keystone Correction (2)

$$\mathbf{v_n} = \mathbf{M} \cdot \mathbf{q_n} \quad q_1 = \begin{pmatrix} 0 \\ 0 \\ q_{1w} \end{pmatrix} \quad q_2 = \begin{pmatrix} 1 \cdot q_{2w} \\ 0 \\ q_{2w} \end{pmatrix} \quad q_3 = \begin{pmatrix} 1 \cdot q_{3w} \\ 1 \cdot q_{3w} \\ q_{3w} \end{pmatrix} \quad q_4 = \begin{pmatrix} 0 \\ 1 \cdot q_{4w} \\ q_{4w} \end{pmatrix}$$

- 9 matrix elements, 4 vertex homogeneous components $\Rightarrow$ 13 unknowns m_{11} – m_{33}, q_{1w} – q_{4w}
- 4 vertex equations $\Rightarrow$ 12 constrictions
- Set m_{33} to 1

- Certainly not the only way to do
- Implementation in keystone.5c a *bit* different

Transformation: Unresolved

- Panning and transformations don't fit together yet
- Input transformations?

Standard Properties

- Property system already in place since 1.2 (1.1?)
  - xrandr ––properties
    xrandr ––output VGA ––set <Property> <Value>
  - New: Set of standard properties, non-standard should be prefixed with “_”
- Mandatory properties
  - Drivers have to have these in order to claim RandR 1.3 support
  - “unknown” is valid value
    So initial support is trivial
- General ideas:
  - (Static) string values provided as ATOMs
  - Values with dashes provide additional information
    e.g. DVI vs. DVI–I TV vs. TV–Composite

Mandatory Properties

- SignalFormat
  - Signal format / physical protocol format valid-values (static) lists all possible formats
  - Values: unknown VGA TMDS LVDS Composite Composite-PAL Composite-NTSC Composite-SECAM SVideo Component DisplayPort
  - Driver changes property if underlying hardware indicates protocol change (e.g. TV formats)
  - X clients change property to select format / protocol (e.g. VGA or TMDS on DVI-I).
- ConnectorType (immutable, static)
  - Values: unknown VGA DVI DVI-I DVI-A DVI-D HDMI Panel TV TV-Composite TV-SVideo TV-Component TV-SCART TV-C4 DisplayPort
  - Good for detecting laptop displays, e.g. in presentation applications

Non-Mandatory Properties

- SignalProperties
  - Array of ATOMs
  - Values for Composite signals:
    NTSC NTSC-M ... PAL PAL-B ... SECAM SECAM-L ...
  - Values for TMDS signals: SingleLink DualLink
  - Values for DisplayPort signals:
    Lane1 Lane2 Lane4 LowSpeed HiSpeed
  - Others not defined yet
  - May be changed by driver and X client
  - Change may fail if e.g. combination not supported
- Not implemented in any driver yet

Non-Mandatory Properties (2)

- ConnectorNumber (immutable, static)
  - Informative property that shows routing of signals
  - Outputs that route to the same connector have same number
- EDID
  - former EDID_DATA
  - Raw EDID data from monitor
  - Provided by Xserver, not driver

Non-Mandatory Properties (3)

- CompatibilityList (immutable)
  - All output+signal format pairs that can be driven together with this output
  - Some encoders can only drive one output at a time
    ⇒ some combinations of outputs cannot be served at all
  - What if 3 or more CRTCs active at the same time?
    Not really analyzed yet – may need matrix / tensor
  - Not implemented in any driver yet
- CloneList (immutable)
  - All output+signal format pairs that can only be driven with the same CRTC in clone mode
  - Some encoders are wired to multiple outputs
    ⇒ some outputs cannot be served independently
- Array of ATOM pairs
- Not implemented in any driver yet

Primary Output Definition

- Standard Question:
  - Where the BEEP is my panel?
- On primary output (1st in list)
- RRSetOutputPrimary
- xrandr ––output VGA ––primary
- Sorts list of outputs and Xinerama information

The End

Questions ?

Novell