

# RandR 1.3

## Transformation, Panning, Properties

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Matthias Hopf

SUSE R&D / Novell





# Side Note: openSUSE X11 Team

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- Novell
  - Stefan Dirsch
  - Egbert Eich
  - Matthias Hopf
  - Luc Verhaegen
- openSUSE
  - Rafael E. Herrera
  - Mark Gray

# So far: RandR 1.2

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- 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

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- 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

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- 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

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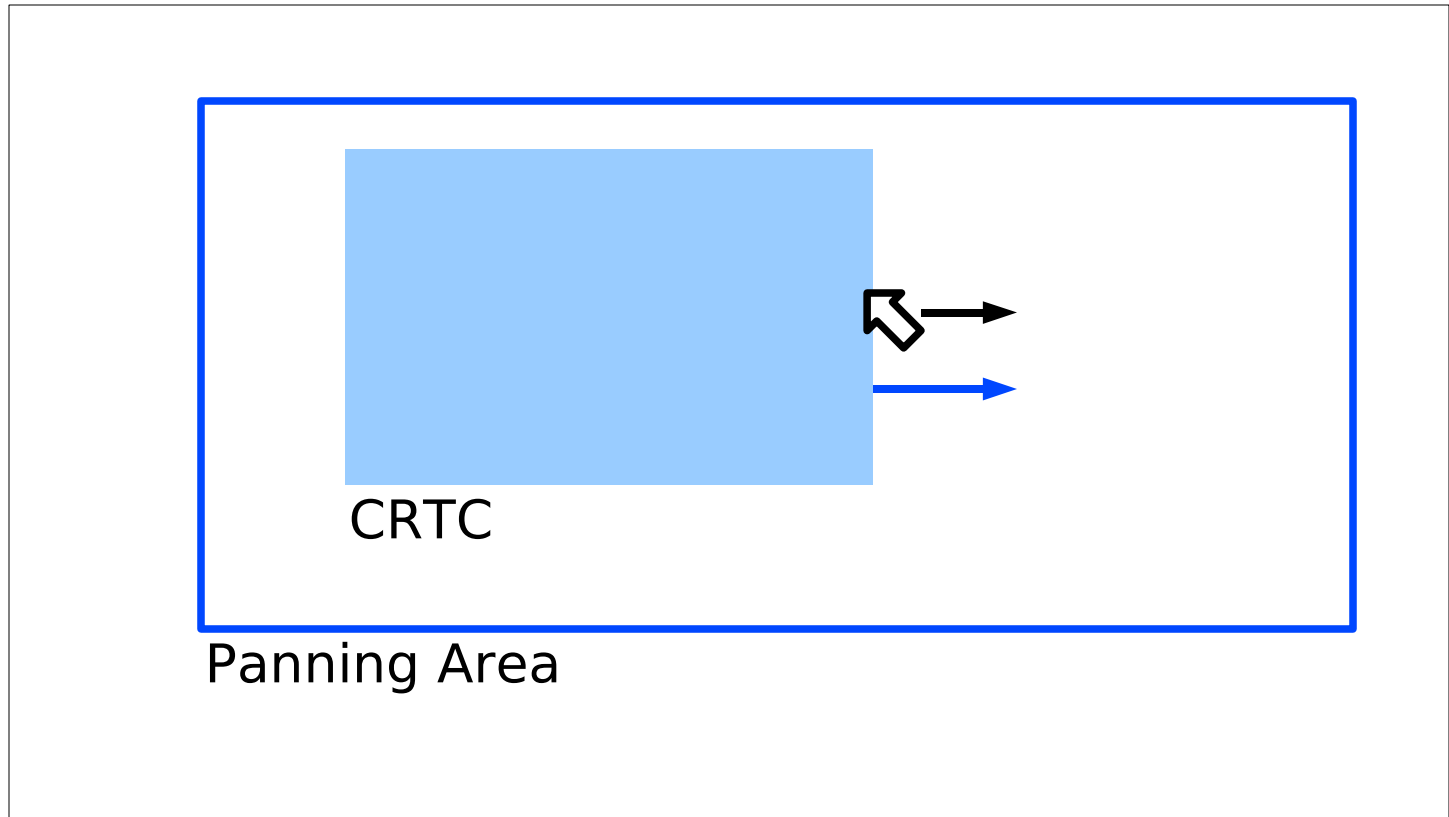
- RRGetScreenResourcesCurrent
  - Equivalent to RRGetScreenResources
  - Just no polling
- Note: You won't get notified of new monitors with this one
- `xrandr --output VGA --current`

# Panning

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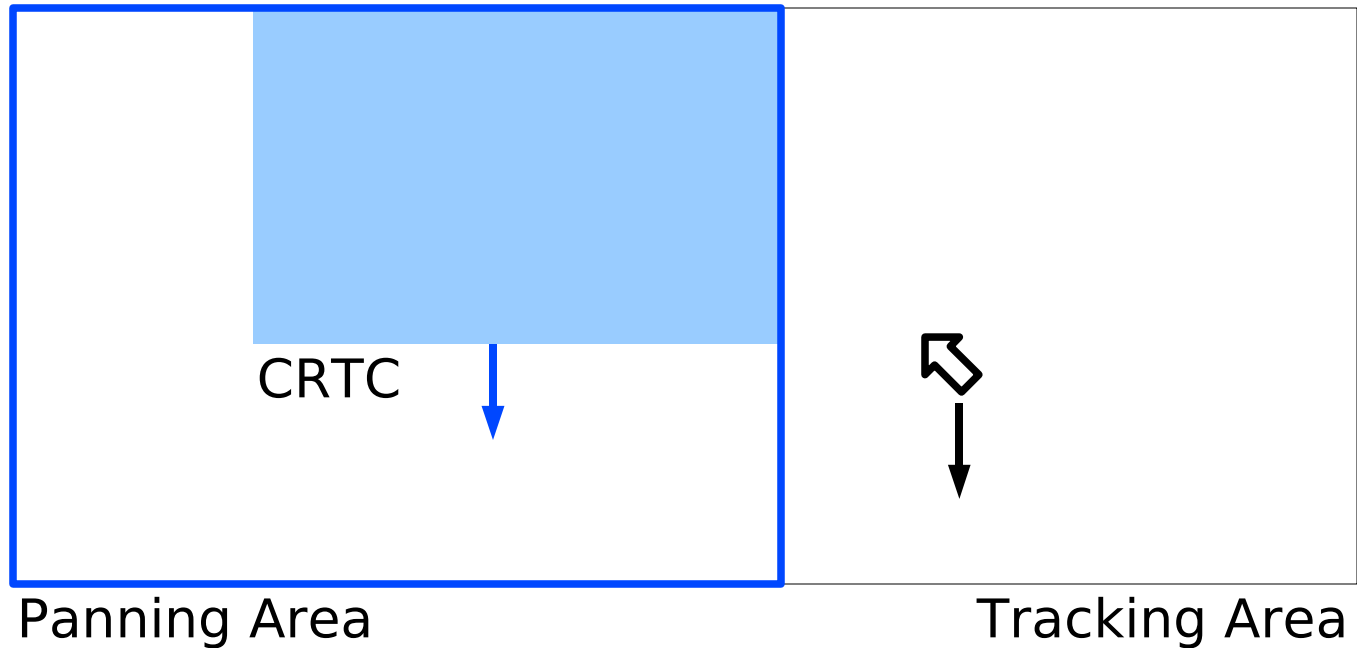
- Change viewport when mouse hits screen borders
  - Needs updated driver for seamless movement:  
xf86CrtcFuncsRec.set\_origin()
  - Otherwise prepare(), mode\_set(), commit() is called, which typically flickers
  - RRGetPanning, RRSetPanning
- xrandr --panning <w>x<h>[+<x>+<y>  
[/<track:w>x<h>+<x>+<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

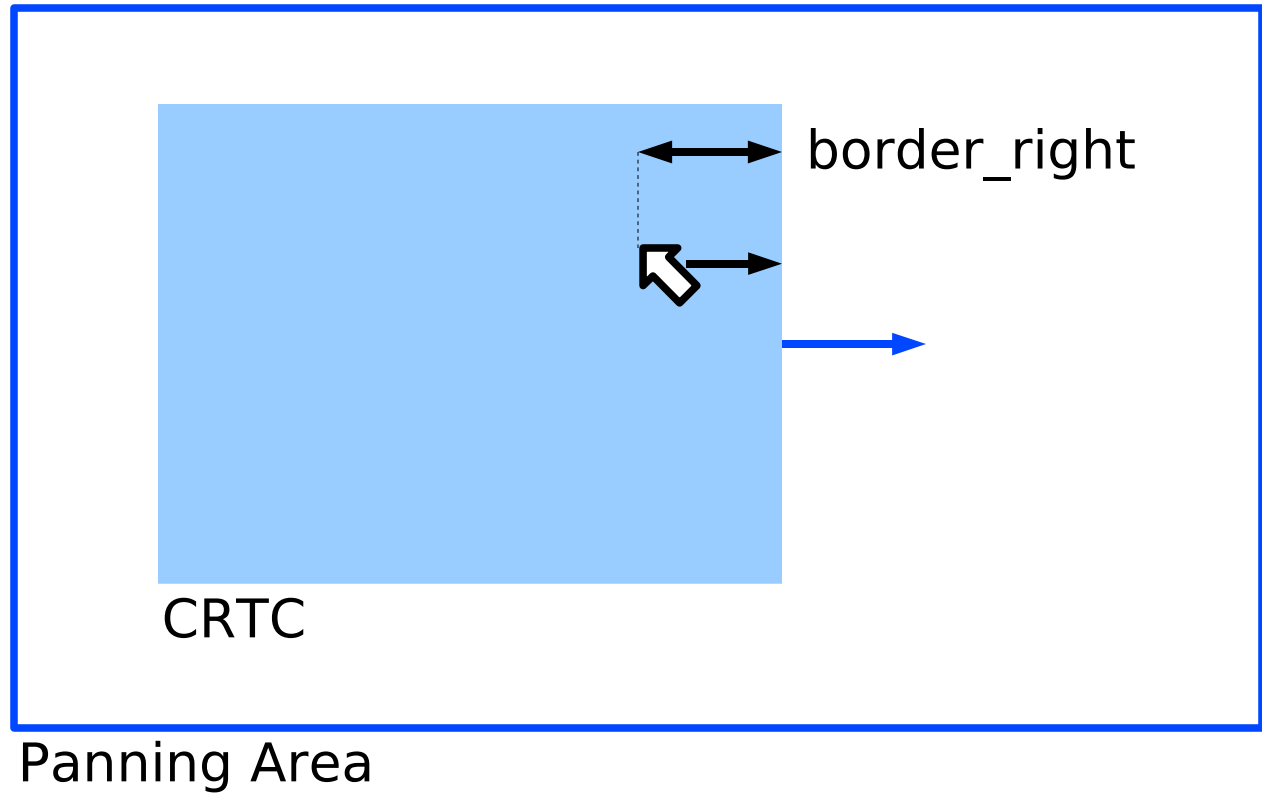


Framebuffer

# Panning: Tracking Area



# Panning: Borders



# Panning: Unresolved

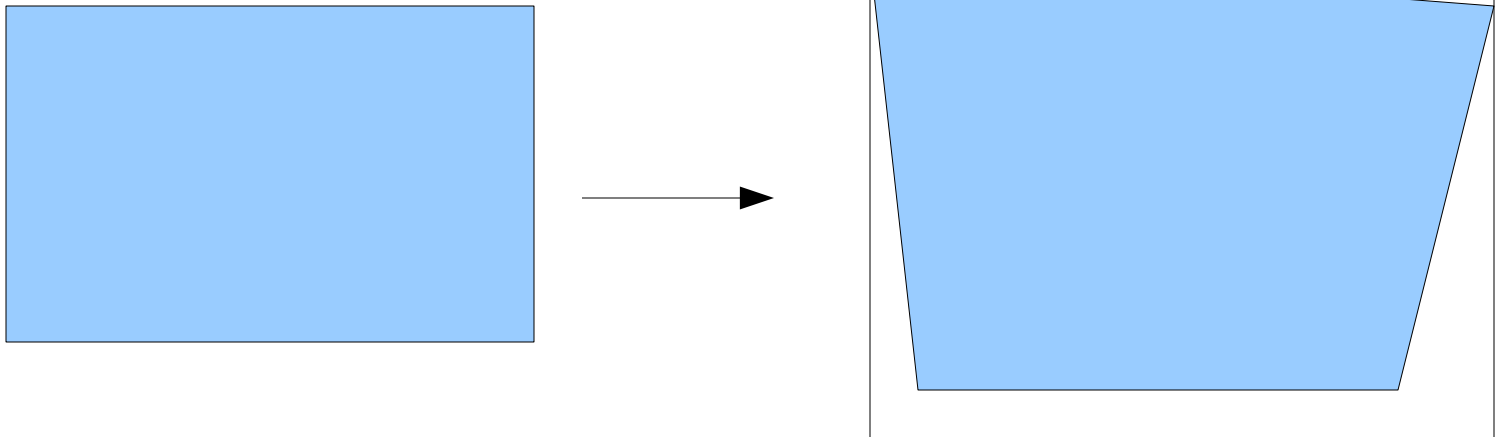
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- RRGetCrtcInfo currently returns CRTC view. CRTC or Panning Area?
- Placement logic in xrandr. Again, CRTC or Panning Area driven?
- Dual head + panning could mean
  - Whole space pans when you get to the side of the virtual space
  - Each physical 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

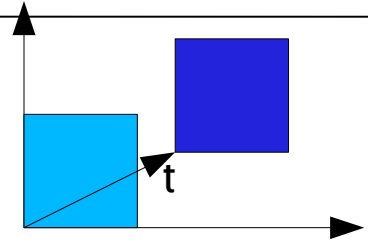
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- Perspective transformation of CRT content
- Rotation, flipping, scaling, keystone correction
- Based on homogeneous coordinate transformation

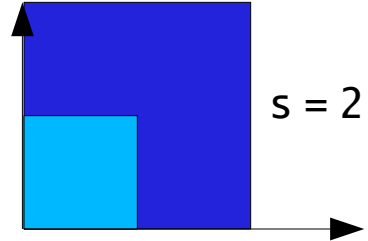


# Transformations: Types

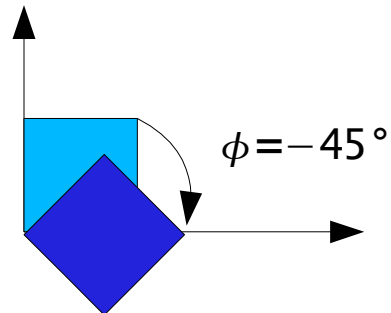
- Translation  $\mathbf{v}' = \mathbf{v} + \mathbf{t}$   $\begin{pmatrix} v'_x \\ v'_y \end{pmatrix} = \begin{pmatrix} v_x + t_x \\ v_y + t_y \end{pmatrix}$



- 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

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

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

- Associative: Transformations can be aggregated:

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

# Homogeneous Transformations

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- 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  $\mathbf{P}(d) = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 1/d & 0 \end{pmatrix}$

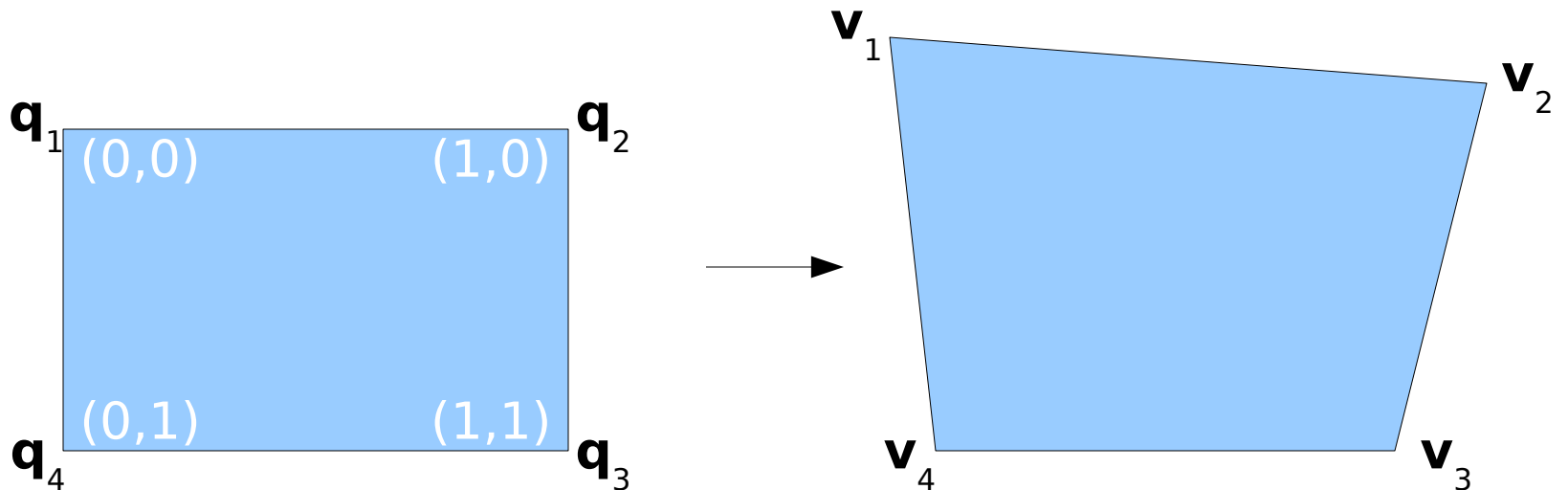
# Transformations in RandR1.3

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- 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  $\mathbf{M}$
- Need inverse transformation  $\Rightarrow \mathbf{M}^{-1}$



## Keystone Correction (2)

$$\mathbf{v}_n = \mathbf{M} \cdot \mathbf{q}_n \quad \mathbf{q}_1 = \begin{pmatrix} 0 \\ 0 \\ q_{1w} \end{pmatrix} \quad \mathbf{q}_2 = \begin{pmatrix} 1 \cdot q_{2w} \\ 0 \\ q_{2w} \end{pmatrix} \quad \mathbf{q}_3 = \begin{pmatrix} 1 \cdot q_{3w} \\ 1 \cdot q_{3w} \\ q_{3w} \end{pmatrix} \quad \mathbf{q}_4 = \begin{pmatrix} 0 \\ 1 \cdot q_{4w} \\ q_{4w} \end{pmatrix}$$

- 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

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

# Standard Properties

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- 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

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- **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

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- 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)

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- 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)

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- **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 CRTC's 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

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



# The End

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Questions ?