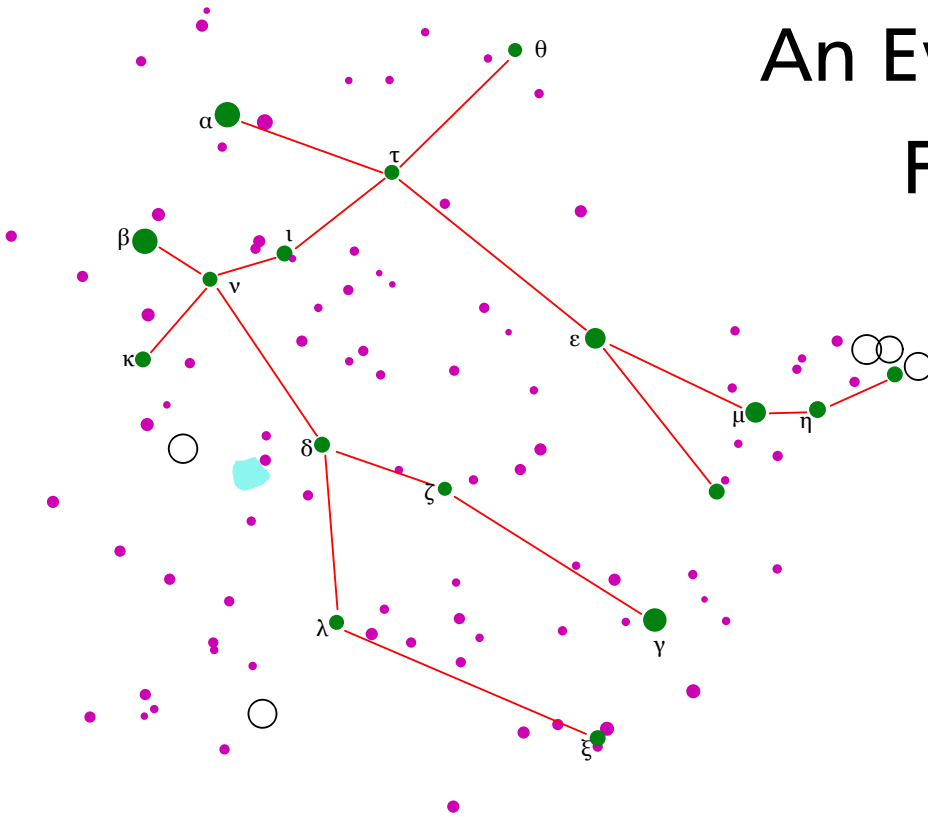


# TWIN

An Even Smaller Window System  
For Even Smaller Devices

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# Motivation

- Sub-PDA devices
- Fast CPUs, tiny memory, tiny screens
- e.g. TI TMS 320 DSP
  - 200MHz CPU
  - 384K RAM
  - 8M Flash





# Embedded X Applications

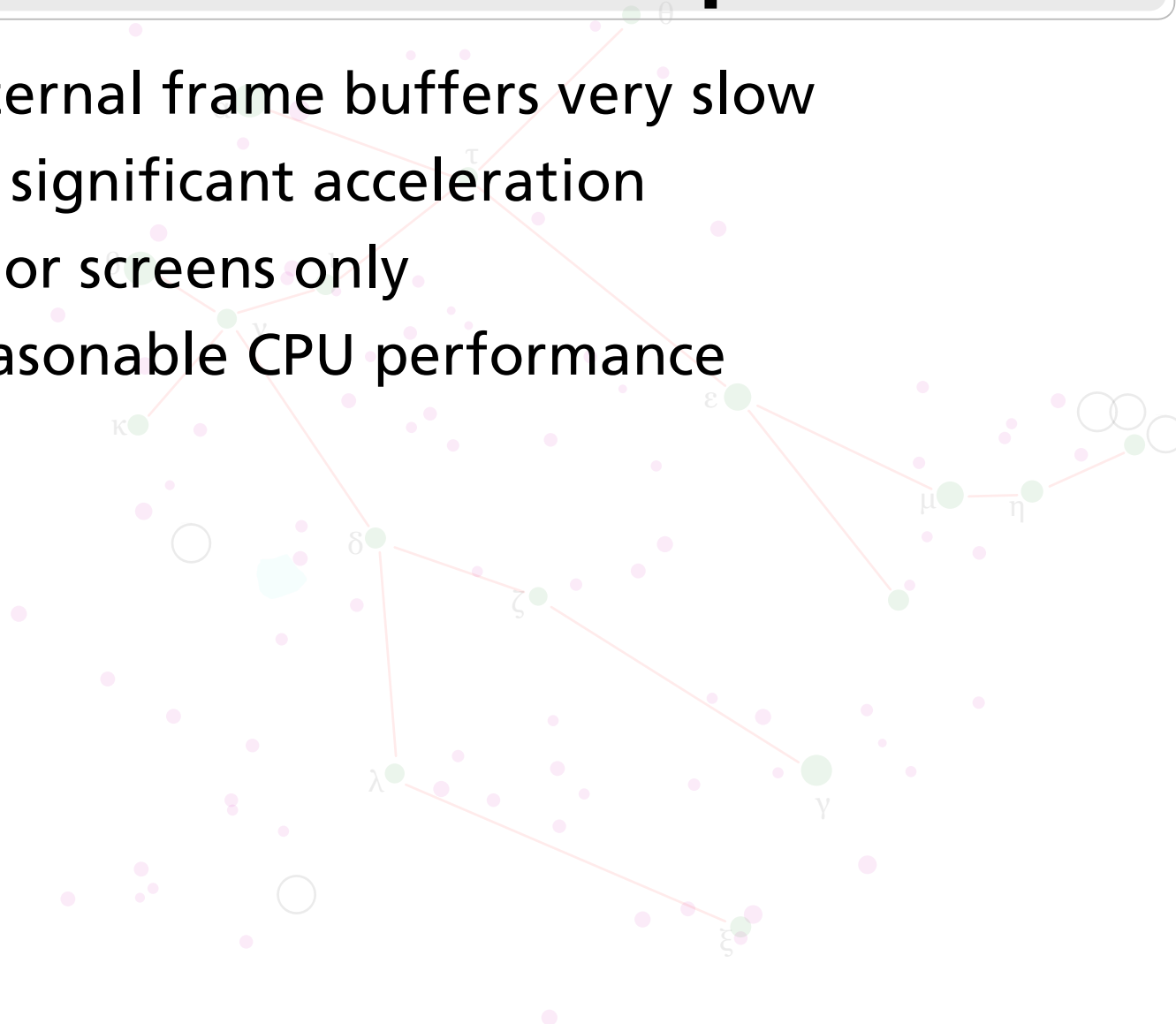
- 16 MB memory
- 4 MB flash
- 200MHz CPU
- 200 × 320 LCD





# Twin Assumptions

- External frame buffers very slow
- No significant acceleration
- Color screens only
- Reasonable CPU performance





# Requirements

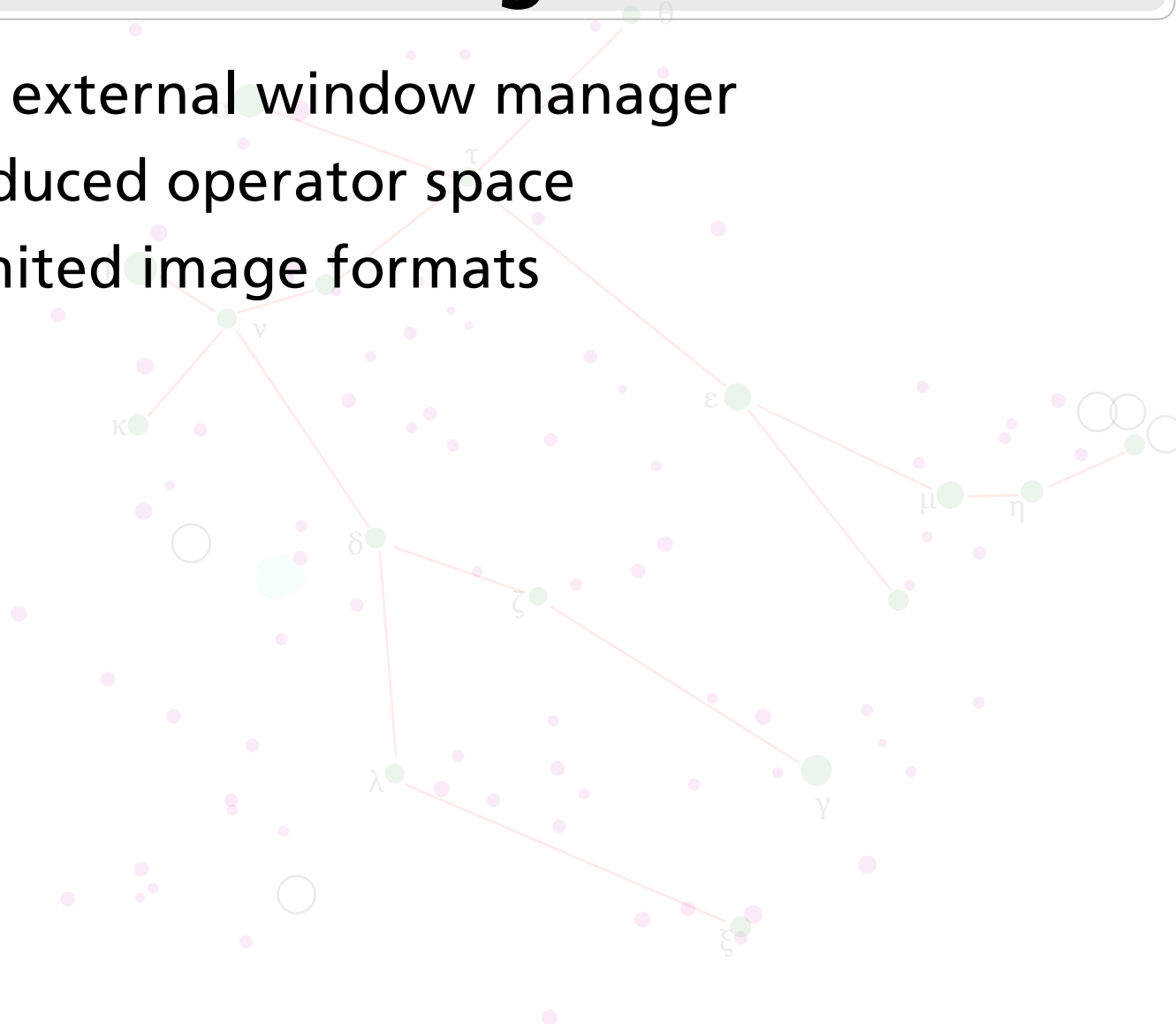
- X + cairo + gtk+
- 100KB memory
- Scalable, proportional text





# Limiting Features

- No external window manager
- Reduced operator space
- Limited image formats





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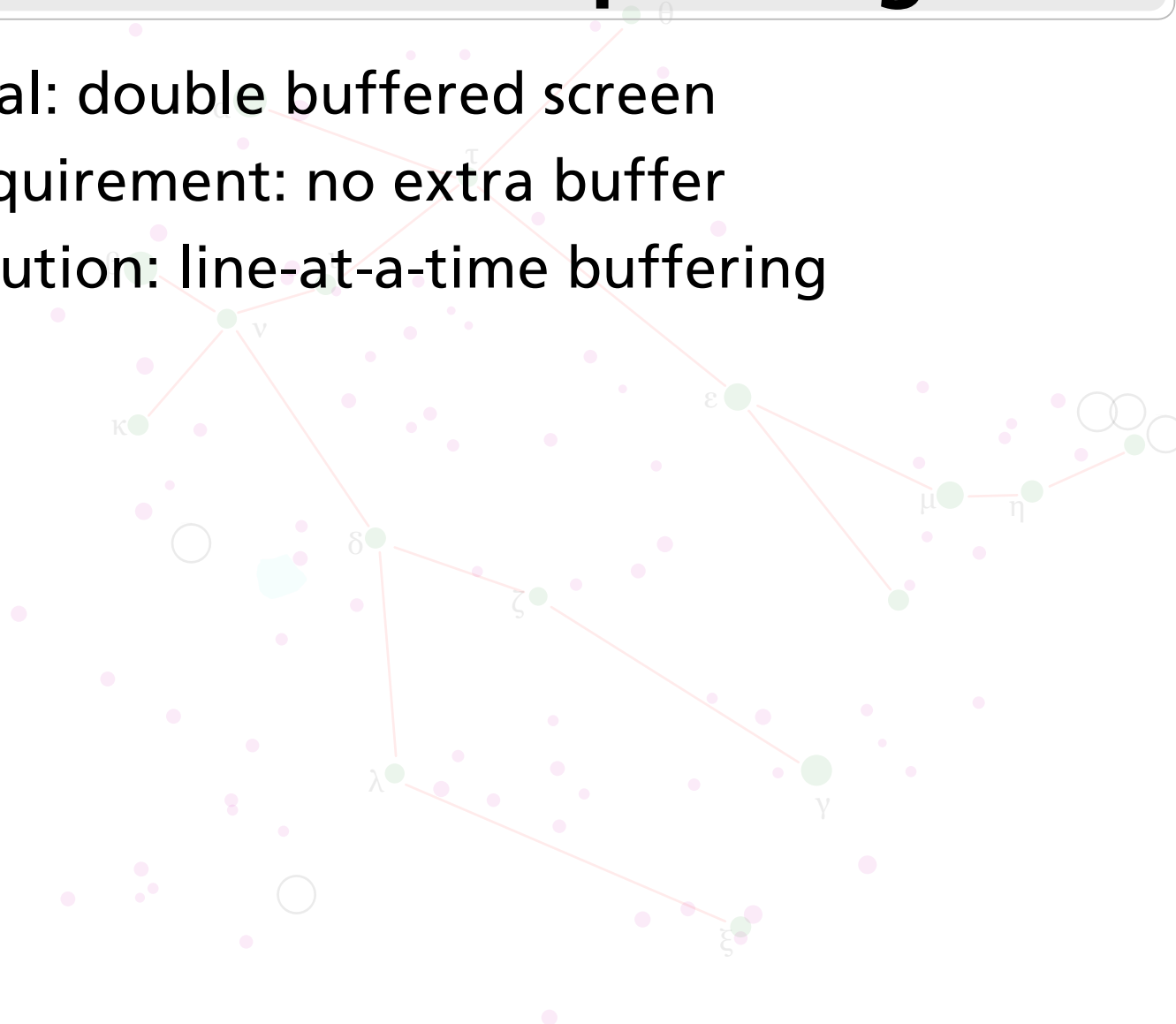
# Windowing

- Composited, just like X
- Windows drawn to off-screen pixmaps
- RGB and ARGB windows supported
- Built-in compositing, not external
- 2D, not 3D



# Screen Updating

- Goal: double buffered screen
- Requirement: no extra buffer
- Solution: line-at-a-time buffering





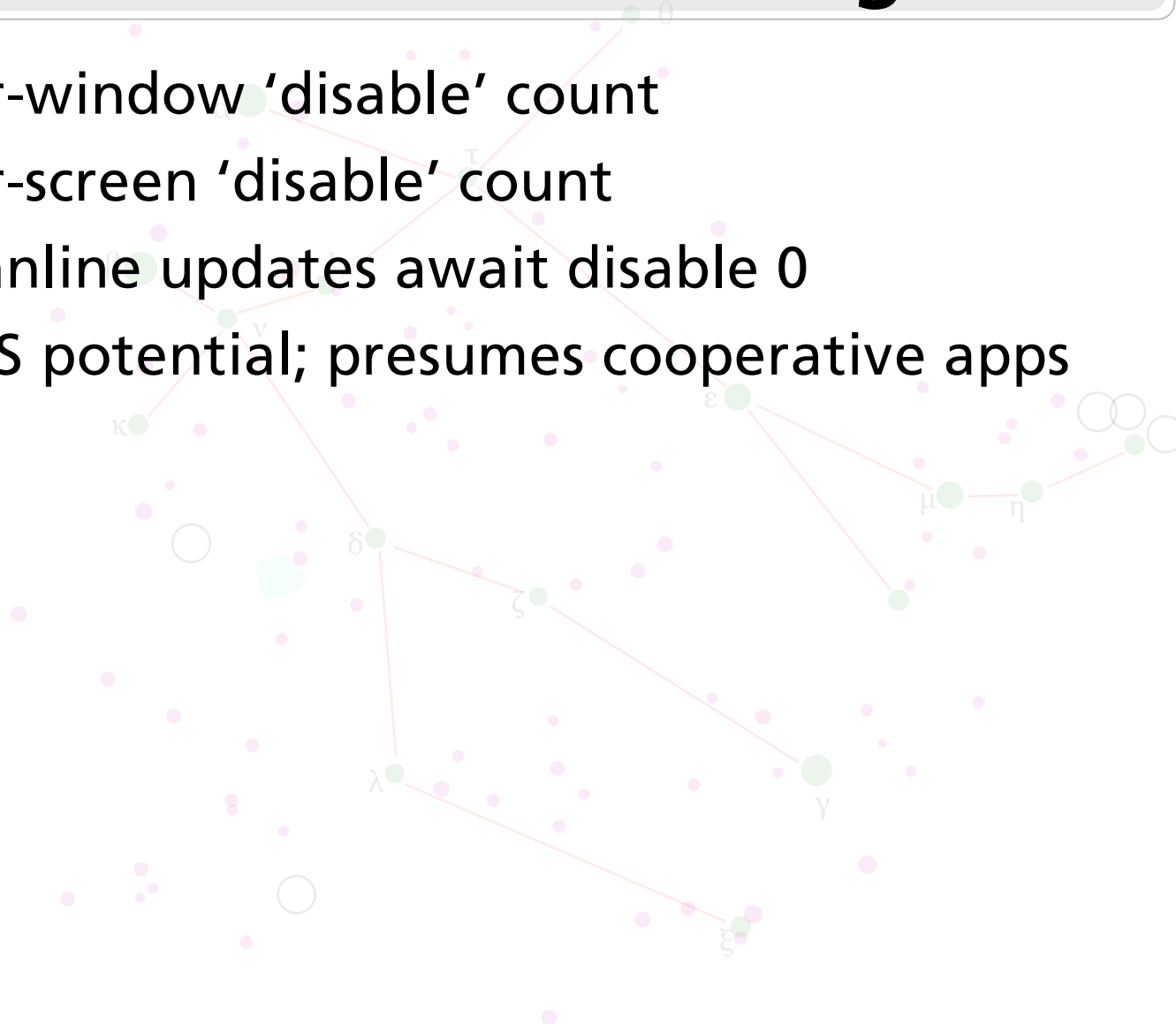


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# Flicker-free Image

- Per-window 'disable' count
- Per-screen 'disable' count
- Scanline updates await disable 0
- DoS potential; presumes cooperative apps





# Rendering

- Looks like the X render extension
- Porter/Duff Compositing (like PDF, GL, etc)
- Plan-9 style compositing function
- $\text{dest} = (\text{src IN mask}) \text{ OVER|SOURCE dst}$

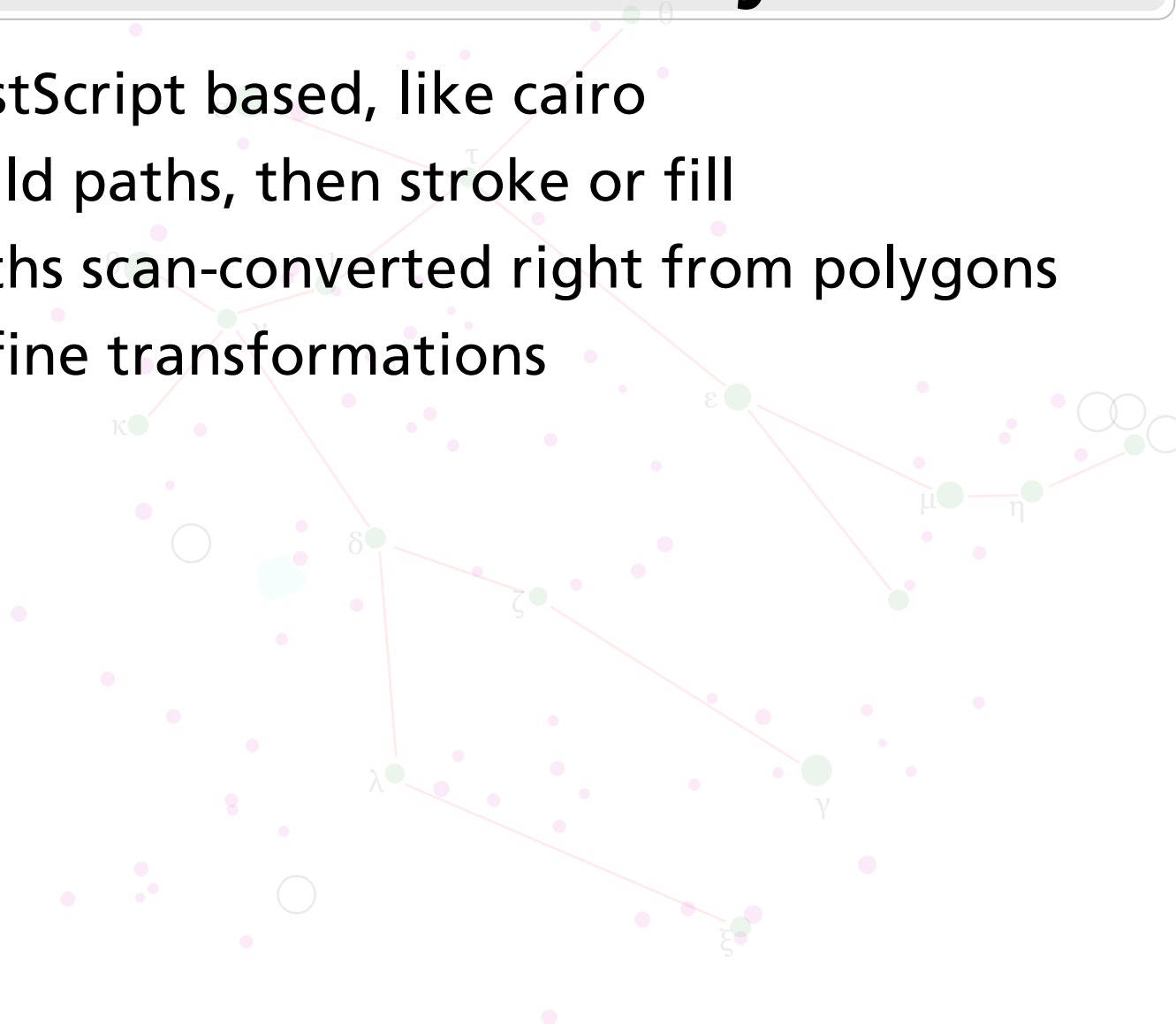


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# Geometry

- PostScript based, like cairo
- Build paths, then stroke or fill
- Paths scan-converted right from polygons
- Affine transformations



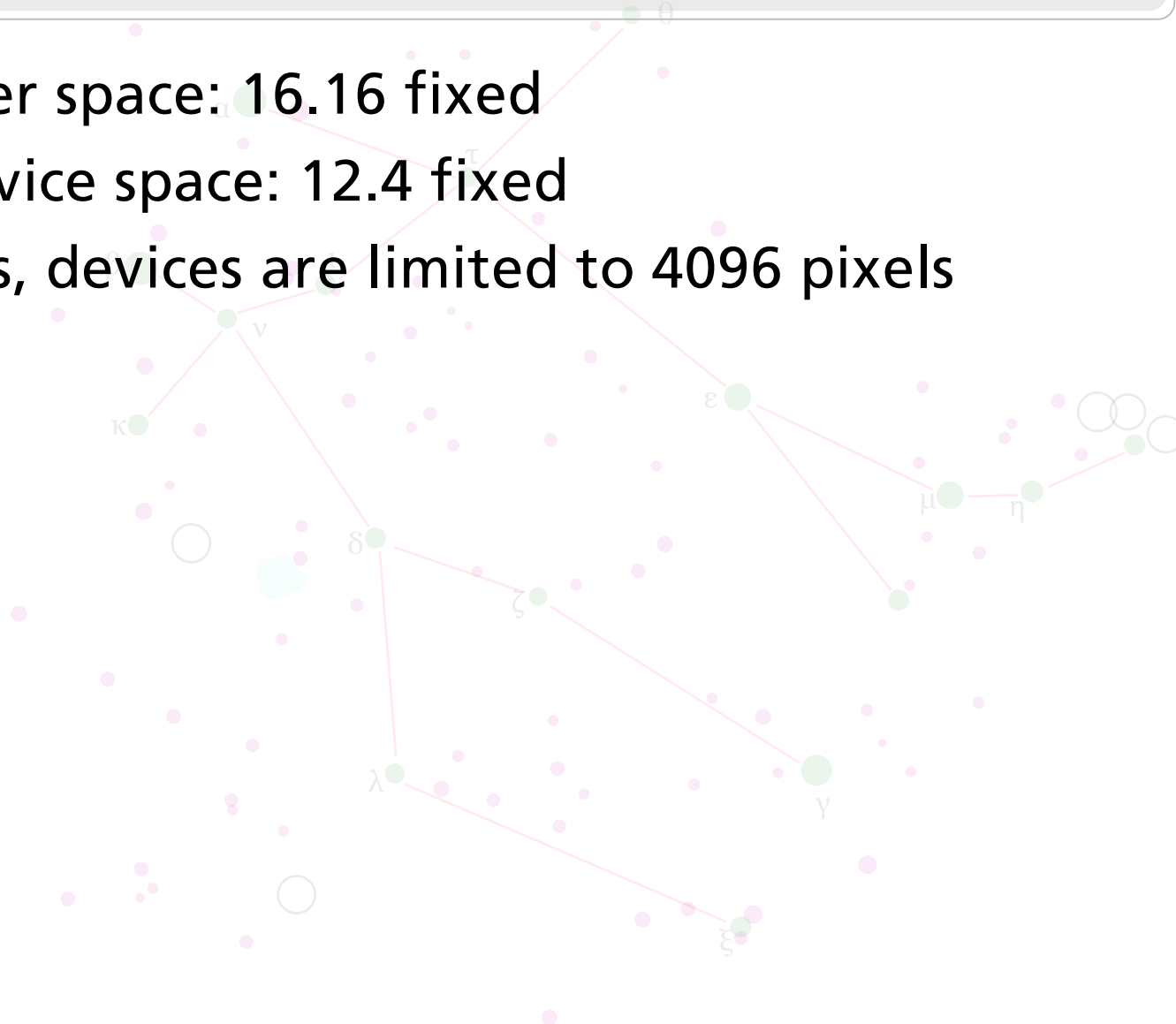


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# Coordinates

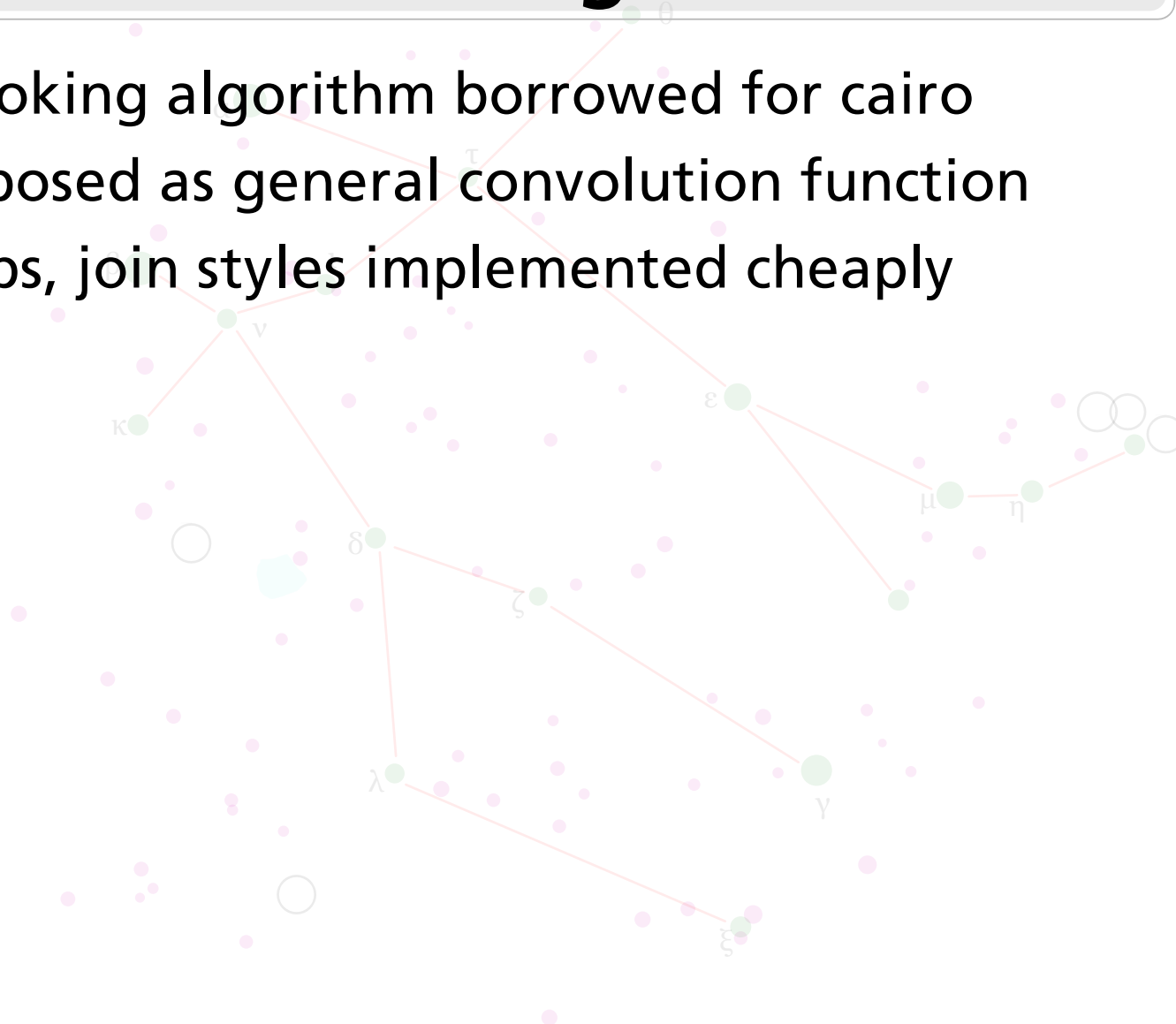
- User space: 16.16 fixed
- Device space: 12.4 fixed
- Yes, devices are limited to 4096 pixels





# Stroking Lines

- Stroking algorithm borrowed for cairo
- Exposed as general convolution function
- Caps, join styles implemented cheaply



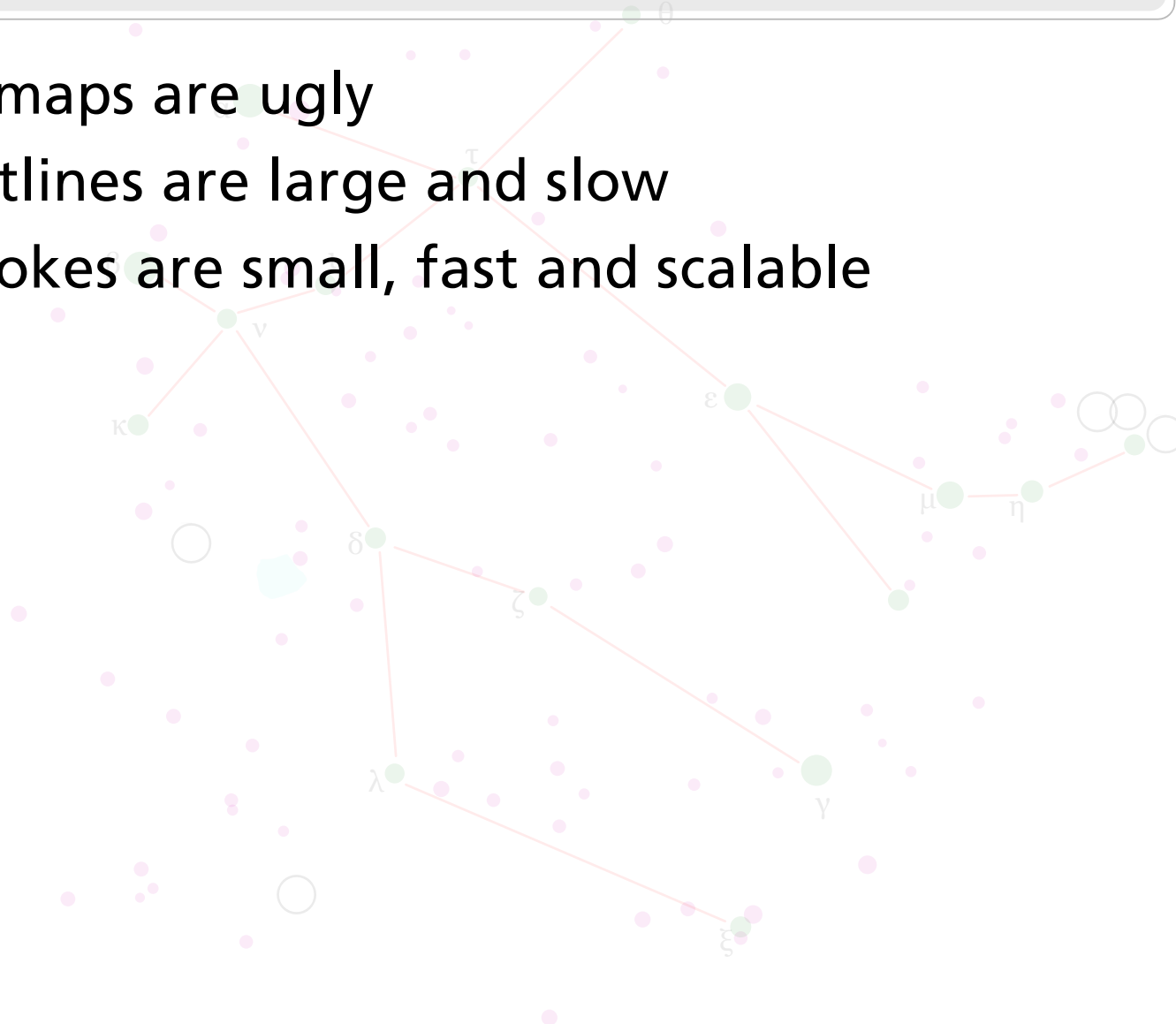


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# Text

- Bitmaps are ugly
- Outlines are large and slow
- Strokes are small, fast and scalable





## Glyph Origin

- Dr. A. V. Hershey worked at U.S NBS
- Designed glyphs for pen plotters
- Glyphs formed from line segments

ABCDEFGHIJKLMNOPQRSTUVWXYZ

abcdefghijklmnopqrstuvwxyz

ABCDEFGHIJKLMNOPQRSTUVWXYZ

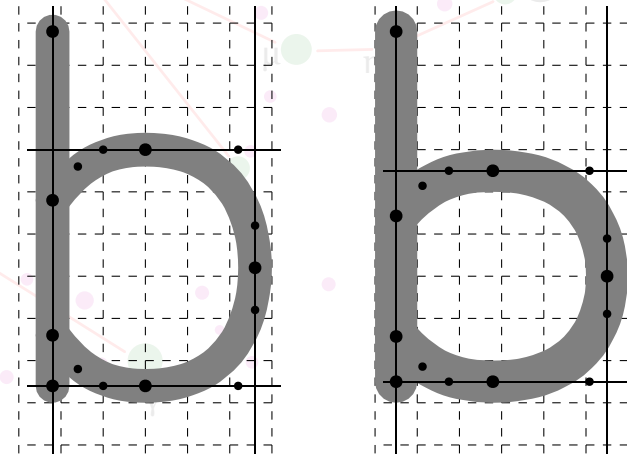
abcdefghijklmnopqrstuvwxyz



# Glyph Changes

- Fitted curved portions with splines
- Extended to cover all of ASCII
- Compiles to 3840 bytes
- Provides roman, oblique, bold and bold-oblique

&&







# Input Model

- Fixed Mouse Model
- Events delivered only to containing window
- Mouse grabbed while button down
- Containment defined by non-translucence
- Keyboard focus explicit



# Toolkit Model

- One screen, which contains
- Many windows, which contain
- One top-level widget, which contains
- One box, which contains
- Many boxes and widgets, the boxes contain
- More boxes and widgets



# Event Model

- Events dispatched immediately, no queue
- Dispatched down the toolkit stack
- Each level dispatches itself





# Layout

- Boxes & Glue
- Widgets and boxes have size and stretch
- Widgets have natural size
- Can compute natural application size

