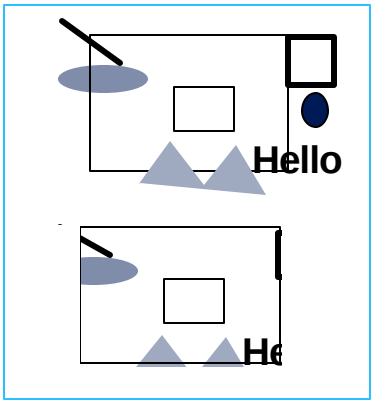
Raster graphics alg's for drawing 2D primitives

- Points of view
  - Application programmer's
  - Package implementor's
  - Scan-converted clipped primitives



Overview …

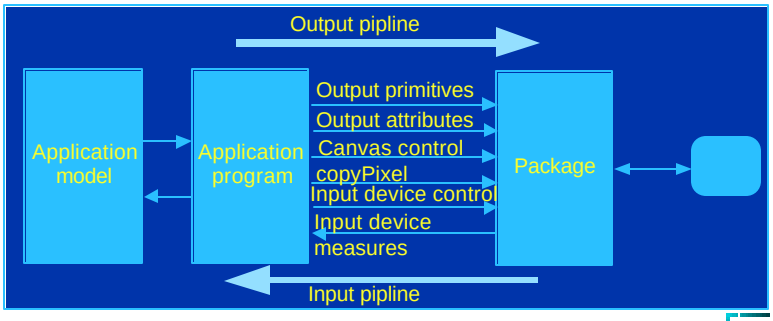
- Implications of display-system architecture …
- Output pipeline ...

Implications of disp-sys architecture …

- Output & input pipelines …
- Displays with frame buffers & display controllers …
- Displays with frame buffers only …
- Hardcopy devices ...

Output & input pipelines

- Output
- Input



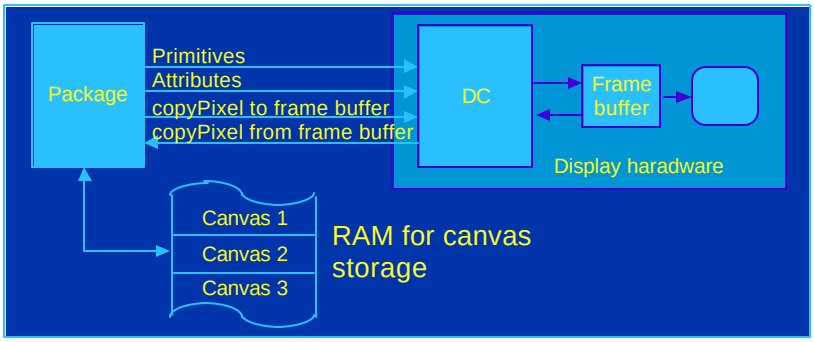
Output

- **Primitive-generation function: What to generate**
- **Attribute functions: How to generate**
- **copyPixel: How to modify image**
- **Canvas-control functions: Where**

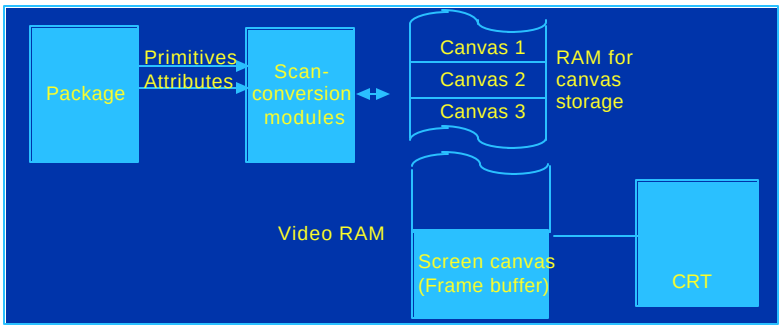
Input

- **User interaction (display) --> measure values**
- **==> modify model or image**

Displays with frame buffers & display controllers …



Displays with frame buffers only …



Hardcopy devices …

- One scan line at a time
  - Package: generate complete bitmap
  - Scan out 1 line at a time
- Entire frame (page)
- Raster Image Processor (RIP): built-in scan-conversion HW
- PostScript engine: interpret program
  - Device independent
  - ==> Primitives + attributes

Output Pipeline …

- Clip primitives then scan-convert
  - ==> Fewer to scan-convert
- Scissoring: Scan-covert then clip
  - Write only visible pixels
- Temp. canvas, copy only clip rectangle
  - Wastes time & space
  - Easy to implement
  - Often for text
- Incremental methods: minimize number of calculations

Scan Converting Primitives

- **primitives**

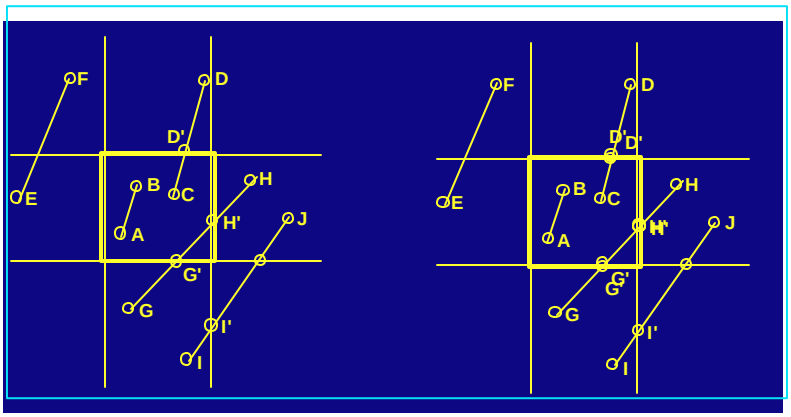
Clipping

- **Clipping endpoints ...**
- **Cases for clipping lines ...**
- **Solving simultaneous equations ...**
- **Cohen-Sutherland Algorithm ...**
- **Parametric Line-Clipping Algorithm ...**

Clipping endpoints

- $x_{min} \leq x \leq x_{max}$
- $y_{min} \leq y \leq y_{max}$

Cases for clipping lines ...

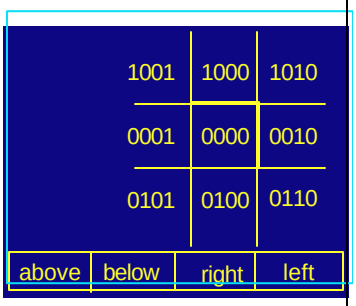


Solving Simultaneous Equations …

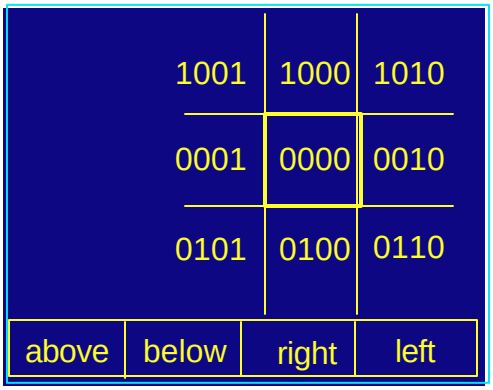
- Both endpoints inside ==> trivially accept
- One inside, one outside ==> find intersection point
- Both outside: may / may not intersect
- Brute force: line equation + clip rectangle edges equation

Cohen-Sutherland Algorithm …

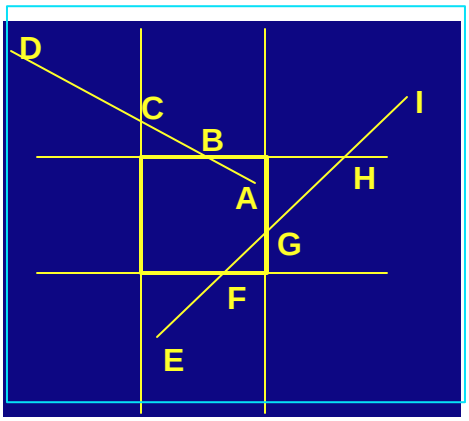
- 1. Check endpoints: trivially accept?
- 2. Region checks: trivially reject?
- 3. Divide into 2 segments s.t. one can be trivially rejected
  - Iterative clip
  - Trivially accept? / reject?
- Example …



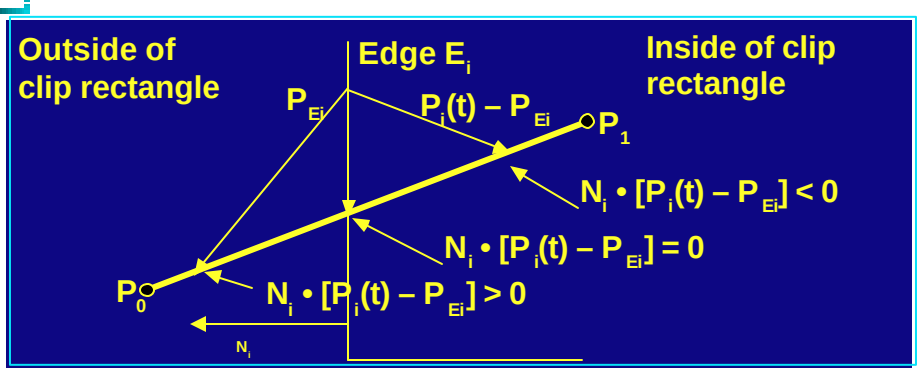
Cohen-Sutherland (cont.)



Cohen-Sutherland example

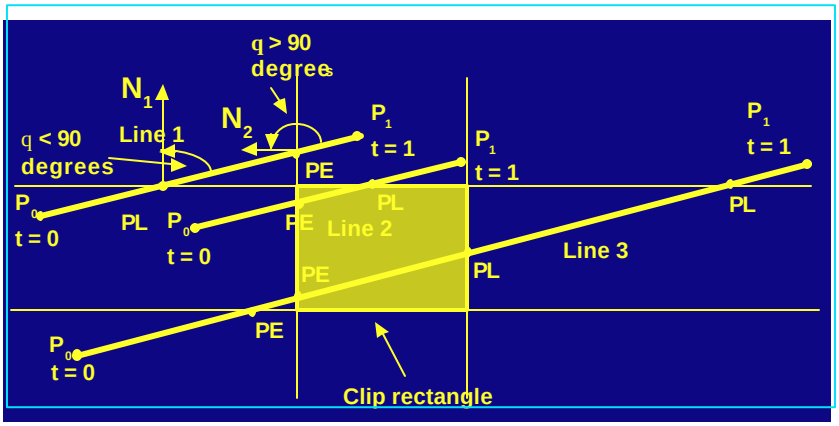


Parametric Line-Clipping algorithm



- **Example ...**

Parametric Line-Clipping example



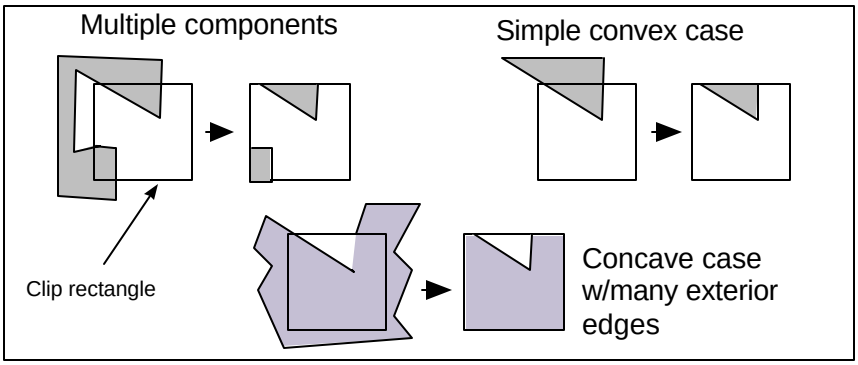
Clipping circles and ellipses

- Accept / reject against square extent
- If intersects, divide into quadrants, repeat accept / reject
- Divide into octants if necessary
- Compute intersection of edge-circle analytically
  - Simultaneous equations
- Scan convert resulting arcs
- Fast scan conversion ==> scissoring faster
- Filled: clip spans then fill

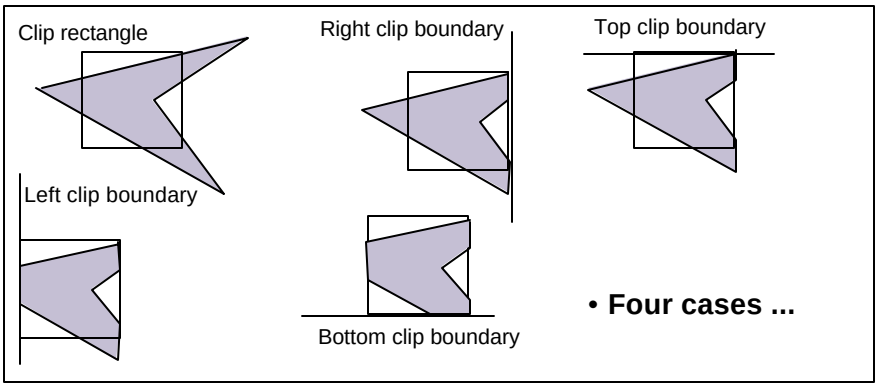
Clipping Polygons

- General …
- Sutherland-Hodgman Algorithm …
  - Four cases …

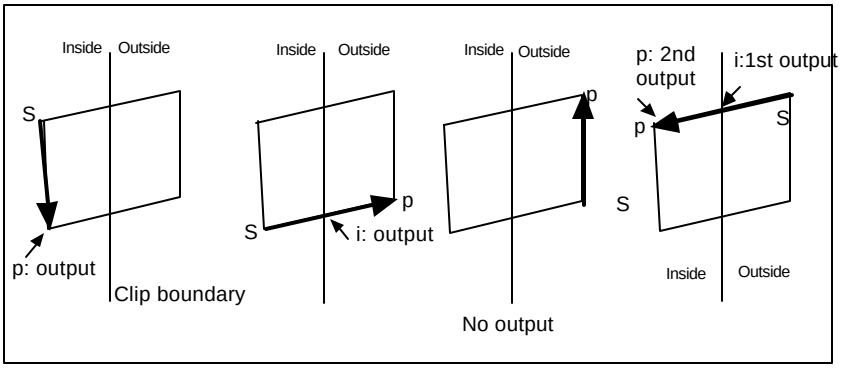
General



Sutherland-Hodgman Algorithm



Four cases



Antialiasing

- **Increasing resolution …**
- **Area sampling …**
  - **Weighted**
  - **Unweighted**
- **Other**

Increasing Resolution

- Best, but
  - Limitations
- Jaggies / staircasing
- Aliasing / antialiasing

Area sampling

- Area represented by pixel
- Unweighted area sampling
  - All pixels equal
- Weighted area sampling
  - Some contribute more than others
  - Based on weight function