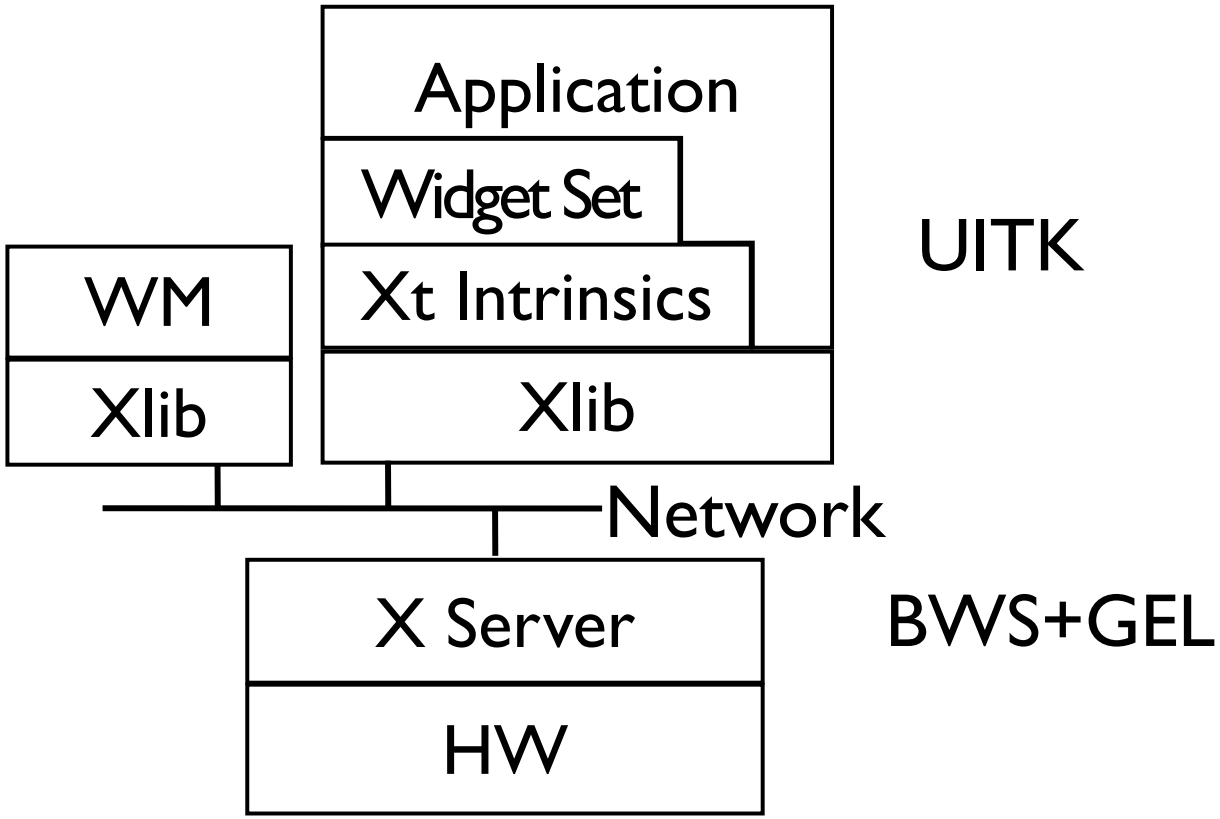
Review: Classic Mac OS

- Designed for the user, not the developer
  - First commercially successful GUI system
  - Technically few advances
  - One address space, one process, "no" OS
  - But revolutionary approach to UI consistency (HI Guidelines)
- Macintosh Toolbox
  - Pascal procedures grouped into Managers, ROM+RAM
  - Extended as technology advanced (color, multiprocessing,...), but architecture was showing its age by late 90s
- Inspiration for other GUIs, esp. MS Windows

The X Window System ("X")

- Asente, Reid (Stanford): W window system for V OS, (1982)
  - W moved BWS&GEL to remote machine, replaced local library calls with synch. communication
  - Simplified porting to new architectures, but slow under Unix
- MIT: X as improvement over W (1984)
  - Asynchronous calls: much-improved performance
  - Application = client, calls X Library (Xlib) which packages and sends GEL calls to the X Server and receiving events using the X Protocol.
  - Similar to Andrew, but window manager separate
  - X10 first public release, X11 cross-platform redesigned

X: Architecture



- X is close to our 4-layer architecture model

X Server

- X11 ISO standard, but limited since static protocol
- X server process combines GEL and BWS
  - Responsible for one keyboard (one EL), but n physical screens (GLs)
  - One machine can run several servers
- Applications (with UITK) and WM are clients
- GEL: Direct drawing, raster model, rectangular clipp.
  - X-Server layers: Device-dependent X (DDX), device-independent X (DIX)
  - BWS can optionally buffer output regions

X Protocol

- Between X server process and X clients (incl. WM)
- asynchronous, bidirectional byte stream, order guaranteed by transport layer
  - Implemented in TCP, but also others (DECnet,...)
  - Creates about 20% time overhead with apps over network
- Four packet types
  - Request, (Client→Server)
  - Reply, Event, Error (Server→Client)
- Packets contain opcode, length, and sequence of resource IDs or numbers

Typical Xlib application (pseudocode)

```
#include Xlib.h, Xutil.h
Display *d; int screen; GC gc; Window w; XEvent e;
main () {
   d = XOpenDisplay(171.64.77.1:0);
   screen = DefaultScreen(d);
   w = XCreateSimpleWindow(d, DefaultRootWindow(d), x,y,w,h,
     border, BlackPixel(d), WhitePixel(d)); // foreground &
     background
   XMapWindow(d, w);
   gc = XCreateGC(d, w, mask, attributes); // Graphics Context
     setup left out here
   XSelectInput(d, w, ExposureMask|ButtonPressMask);
   while (TRUE) {
     XNextEvent(d, &e);
       switch (e.type) {
          case Expose: XDrawLine (d, w, gc, x,y,w,h); break;
          case ButtonPress: exit(0);
} } }
```


X: Resources

- Logical: pixmap, window, graphic context, color map, visual (graphics capabilities), font, cursor
- Real: setup (connection), screen (several), client
- All resources identified via RIDs
- Events: as in ref. model, from user, BWS, and apps, piped into appropriate connection
- X Server is simple single-entrance server (round-robin), user-level process

Window Manager

- Ordinary client to the BWS
- Communicates with apps via hints in X Server
- Look&Feel Mechanisms are separated from Look&Feel Policy
- Late refinement (session, user, application, call)

Window Manager

- Dynamically exchangeable, even during session
  - twm, ctwm, gwm, mwm (Motif), olwm (OpenLook), rtl (Tiling), ...
  - Implement different policies for window & icon placement, appearance, all without static menu bar, mostly pop-ups, flexible listener modes
- No desktop functionality (separate app)
- Only manages windows directly on background (root) window, rest managed by applications (since they don't own root window space)

X: UITK

- X programming support consists of 3 layers
- Xlib:
  - Lowest level, implements X protocol client, procedural (C)
  - Programming on the level of the BWS
  - Hides networking, but not X server differences (see "Visual")
  - Packages requests, usually not waiting for reply (async.)
  - At each Xlib call, checks for events from server and creates queue on client (access with XGetNextEvent())
  - Extensions require changing Xlib & Xserver source & protocol

X: UITK

- Xlib offers functions to create, delete, and modify server resources (pixmaps, windows, graphic contexts, color maps, visuals, fonts), but app has to do resource composition
- Display (server connection) is parameter in most calls

- X Toolkit Intrinsics (Xt)
  - Functions to implement an OO widget set class (static) hierarchy
  - Programming library and runtime system handling widgets
  - Exchangeable (InterViews/C++), but standard is in C
  - Each widget defined as set of "resources" (attributes) (XtNborderColor,...)

X: UITK

- X Toolkit Intrinsics
  - Just abstract meta widget classes (Simple, Container, Shell)
  - At runtime, widgets have 4 states
    - Created (data structure exists, linked into widget tree, no window)
    - Managed (Size and position have been determined—policy)
    - Realized (window has been allocated in server; happens automatically for all children of a container)
    - Mapped (rendered on screen)—may still be covered by other window!

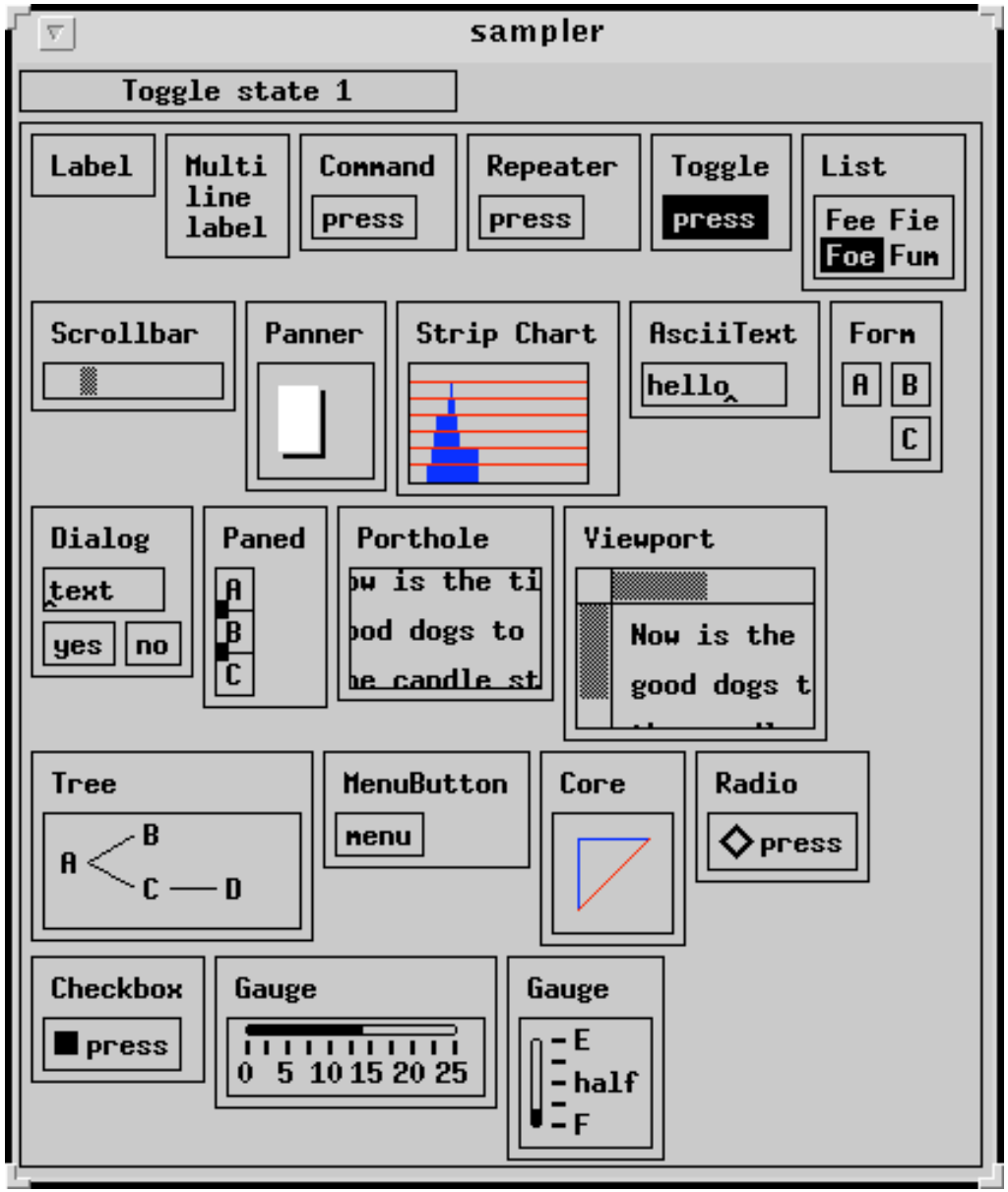
UITK

- X Toolkit Intrinsics
  - Xt Functions (XtRealizeWidget(),...) are generic to work with all widget classes
  - Event dispatch:
    - Defined for most events in translation tables (I→A) in Xt
    - →Widgets handle events alone (no event loop in app)!
    - App logic in callback functions registered with widgets

Widget Sets

- Collection of user interface components
- Together with WM, define look&feel of system
- Several different ones available for X
  - Athena (original, simple widget set, ca. 20 widgets, 2-D, no strong associated style guide) — Xaw... prefix
  - Motif (Open Software Foundation, commercial, 2.5-D widget set, >40 widgets, industry standard for X, comes with style guide and UIL)—Xm... prefix
- Programming model already given in Intrinsics
  - Motif just offers convenience functions

Athena Widget Set



- Original, free, extensible
- Ugly, simple
- Class hierarchy:
  - *Simple* — Base class for all other Athena widgets. Does nothing, but adds new resources such as cursor and border pixmap.

Athena

- Standard widgets:
  - *Label* Draws text and/or a bitmap.
  - *Command* Momentary push-button
  - *Toggle* Push-button with two states.
  - *MenuButton* Push-button that brings up a menu.
  - *Grip* Small widget used to adjust borders in a Paned widget.
  - *List* Widget to allow user to select one string from a list.
  - *Scrollbar* Widget to allow user to set a value; typically to scroll another widget.
  - *Box* Composite widget which simply lays children out left-to-right.
  - *Form* Constraint widget which positions children relative to each other.
  - *Dialog* Form widget for dialog boxes.
  - *Paned* Constraint widget letting user adjust borders between child widgets.

  - *Text* Base class for all other text classes.
  - *TextSink* Base class for other text sinks.
  - *TextSrc* Base class for other text sources (subclasses for ASCII and multi-byte text)

  - *SimpleMenu* Shell which manages a simple menu.
  - *Sme* RectObj which contains a simple menu entry (blank).
  - *SmeBSB* Menu entry with a string and optional left & right bitmaps.
  - *SmeLine* Menu entry that draws a seperator line.

Athena

- Special widgets:
  - *Repeater* Command that repeatedly calls its associated callback function for as long as it's held.
  - *Panner* Widget to allow user to scroll in two dimensions.
  - *StripChart* Widget to display a scrolling graph.
  - *Porthole* Composite widget which allows a larger widget to be windowed within a smaller window. Often controlled by Panners.
  - *Viewport* Constraint widget, like a Porthole with scrollbars.
  - *Tree* Constraint widget, lays its children out in a tree.