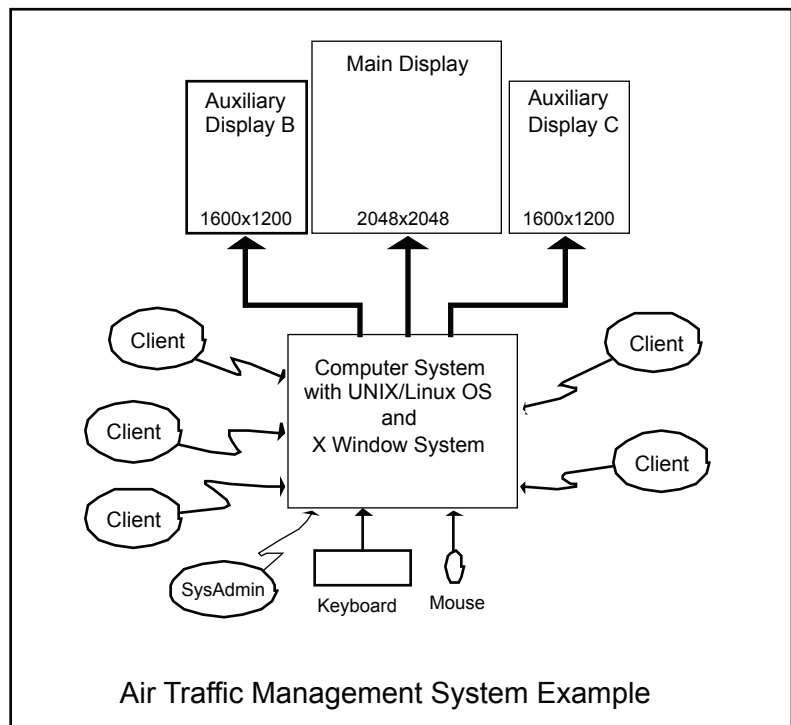SECAP
X Session Capture
Record/Playback Feature for X Window System

Functional Description

SECAP is a optional feature that is available in some versions of Xi Graphics' Summit Series of Accelerated-X™ graphics sub-systems (X servers and graphics drivers). The feature is integrated into the X server and is designed to provide a low-overhead mechanism to record in real time the graphics state of a computer system for later playback.   When Recording is commenced, a "Snapshot" of the state of the graphics sub-system, including the displayed images and state(s) of the graphics hardware and of the X server and graphics driver(s) software is saved along with a time stamp. Subsequent incoming (to the X server) X protocol packets (including packets internally generated from mouse and keyboard events) are time-stamped and recorded in a stream until the next Snapshot or until the Recording Session is terminated.

For each Snapshot and its associated X protocol data, two separate files are created - one for Snapshot data and another for subsequent protocol data associated with the snapshot. Data can be stored into the files in compressed or uncompressed form. Files for each snapshot are sequentially numbered for convenient management of Playback selections.

Snapshots capture all of the image data being displayed at the "T zero" time of the Snapshot, and the state of the graphics system, in an "atomic" (i.e., non-interruptable) operation. The X server is not allowed to update any images or change any graphics states during this atomic operation. Thus the Snapshot must be very fast so as not to cause any noticable delay in image updating (noticable to the operators of Air Traffic

Air Traffic Management System Example

Control systems, for example). Large systems with a 2Kx2K display and perhaps one or more smaller displays generally require less than 500 milliseconds to capture a snapshot. An example of an ATC system configuration is shown in the Figure above.

The time between snapshots during sessions where SECAP Recording is employed is variable (controlled by customer's requirements), but a typical interval between snapshots might be ten minutes.   After a snapshot is captured, the snapshot data (can be upwards of 30MB for systems with large and multiple displays) and subse-quent X protocol packet data are streamed out to disk in background while normal graphics operations are proceeding. The amount of system CPU power required to support SECAP

recording will vary with the number of and speed of CPUs and the bus bandwidth, but some typical dual CPU system configurations have shown that about 10% of the system overhead is required for SECAP recording when data compression is not used, and about 25% when compression is used.

Features and Benefits

SECAP was designed by the Accelerated-X team of X server and graphics driver developers at Xi Graphics. An X server extension, the XRAP Extension, was developed as the foundation on which SECAP relies. The result is a tightly integrated, highly efficient, easy to use capability that can be employed on UNIX/Linux operating systems that use the X Window System. Recording is accomplished by capturing - "snapshoting" - the state of the graphics sub-system at any given moment and then time-
stamping and recording each subsequent incoming command from applications ("clients") and operator–created events (keyboard/mouse inputs) that can cause a graphics state change. The recording is transparent to the client applications, allowing SECAP to be used with existing applications without modifications.

• **Transparent Recording -** Because SECAP is recording at the graphics sub-system level rather than at the applications level, the various applications ("clients") do not need to know that recording is being done, whether the running clients are local or remote or both. Existing clients do not have to be modified in order to work with SECAP, and new applications being developed do not have to be aware of SECAP.

- • **Transparent Recording**
- • **Fast Snapshots**
- • **Low Overhead Recording**
- • **Compression Option**
- • **Sinple Control Interface**
- • **Internal or External Master Clock**

• **Fast Snapshots -** Systems that use typical high performance, multi-display graphics cards, such as those from ATI, 3Dlabs, and Matrox can benefit from exceptionally fast snapshots, even with multiple cards and several large monitors in the system. Snapshot times as loSnapw as 100 milliseconds have been measured on systems with one large monitor and a single graphics card. Two graphics cards and three monitors require additional snapshot time, of course, bSnapshotut the tdiscernable pause in image updates in a large system with multiple cards and several displays.

• **Low Overhead Recording -** An important design objective of SECAP was the ability to record the graphics activities of a large system that is operating in a critical environment - such as Air Traffic Management - without placing undue load on the system. That is, the operator should not see any appreciable degradation of the system performance when SECAP is recording. Depending upon the computer hardware used in large systems, SECAP generally should not (does not) require more than about 10% of the compute power of the system when compression is not used.

• **Compression Option -** Data recording can be accomplished in two formats - SECAP Format, and SECAP Compressed Format. SECAP format is basically raw imae and protocol data that has been slightly transformed and time-stamped. SECAP Compressed Format is the same data that has also been compressed prior to recording. Compression rates of 30-to-1 have been obtained, and will vary with each system according to the applications.
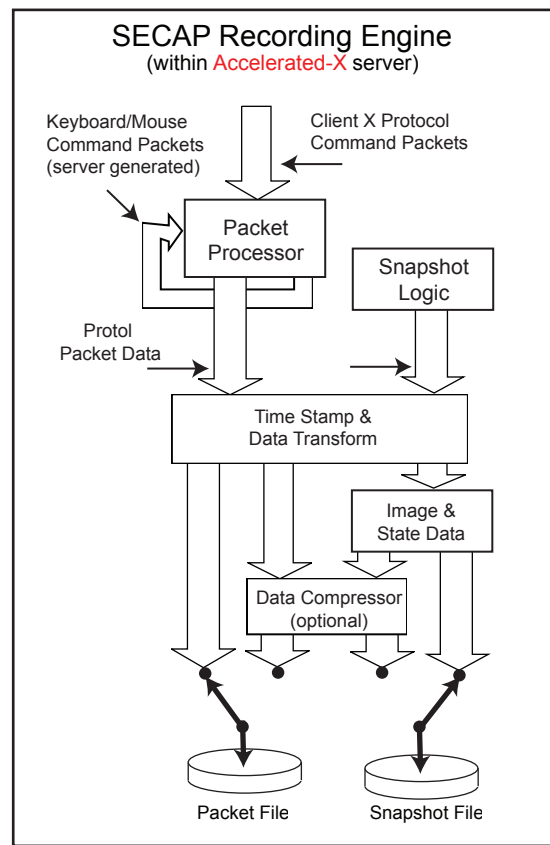
• **Simple Control Interface -** Much like controlling a VCR, SECAP has a Record command and a Play(back) command. Other than a few items such as specifying time between snapshots, compression or not, naming files, etc., there is not much else to it. The command utilities are provided, along with SECAP library 'libXrap' and header files (API sources) for those who wish to develop custom applications that interface directly with the XRAP Extension.

• **Internal or External Master Clock -** SECAP timing can be obtained from the System clock, or from an external (Master) source.

• **Multiple/Remote Application Recording -** Because SECAP records at the graphics sub-system level, it is able to record commands from any and all clients whether local or remote. With the X Window System, clients on other computers and even in other countries can send commands to the system (one of the great features of UNIX systems using the X Window System). SECAP does not require that all clients be aware of SECAP, only the client (or clients) that have the authority to envoke SECAP. The code to invoke SECAP can be added to an existing client, or customers can use code provided by Xi Graphics.

• **Accurate Record of Events -** Graphics sub-system recording produces a more accurate method of recording the actual displays seen by operators of a system. Recording at the applications level involves recording what was intended to be sent to the graphics system, but does not record whether the X server actually got the command. It is a small, but important, distinction to be considered for critical systems.   In such systems, the use of a proxy X server should be avoided for reasons of safety, accuracy, and speed, since it is basically a "kludge."

SECAP Recording Engine
(within Accelerated-X server)

• **Graphics Card Selection -** Xi Graphics has made a business for over ten years developing X servers and graphics drivers to support many graphics cards and graphics architectures from many manufacturers of such cards/architectures, using confidential data provided by the manufacturers. SECAP is available for operation on a number of graphics cards, allowing system designers considerable flexibility in choosing graphics hardware.

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