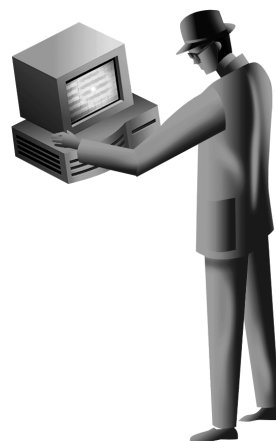

Citrix MetaFrame for UNIX[®] Operating Systems and ICA: Performance Characteristics

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Internet Application Server Products

Citrix Systems, Inc.



CITRIX[®]

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The aim of this document is to give you an overview of the performance characteristics of MetaFrame for UNIX Operating Systems. We focus on network usage of the ICA protocol, in particular compared to the X11 protocol, and also give some indications of server scalability and sizing.

This document gives a general introduction to the Citrix MetaFrame for UNIX Operating Systems and ICA. Please visit the Citrix website at <http://www.citrix.com> for more information and details of members of the Citrix Solutions Network members, who are able to provide the MetaFrame for UNIX Operating Systems product range.

General introduction: MetaFrame for UNIX Operating Systems

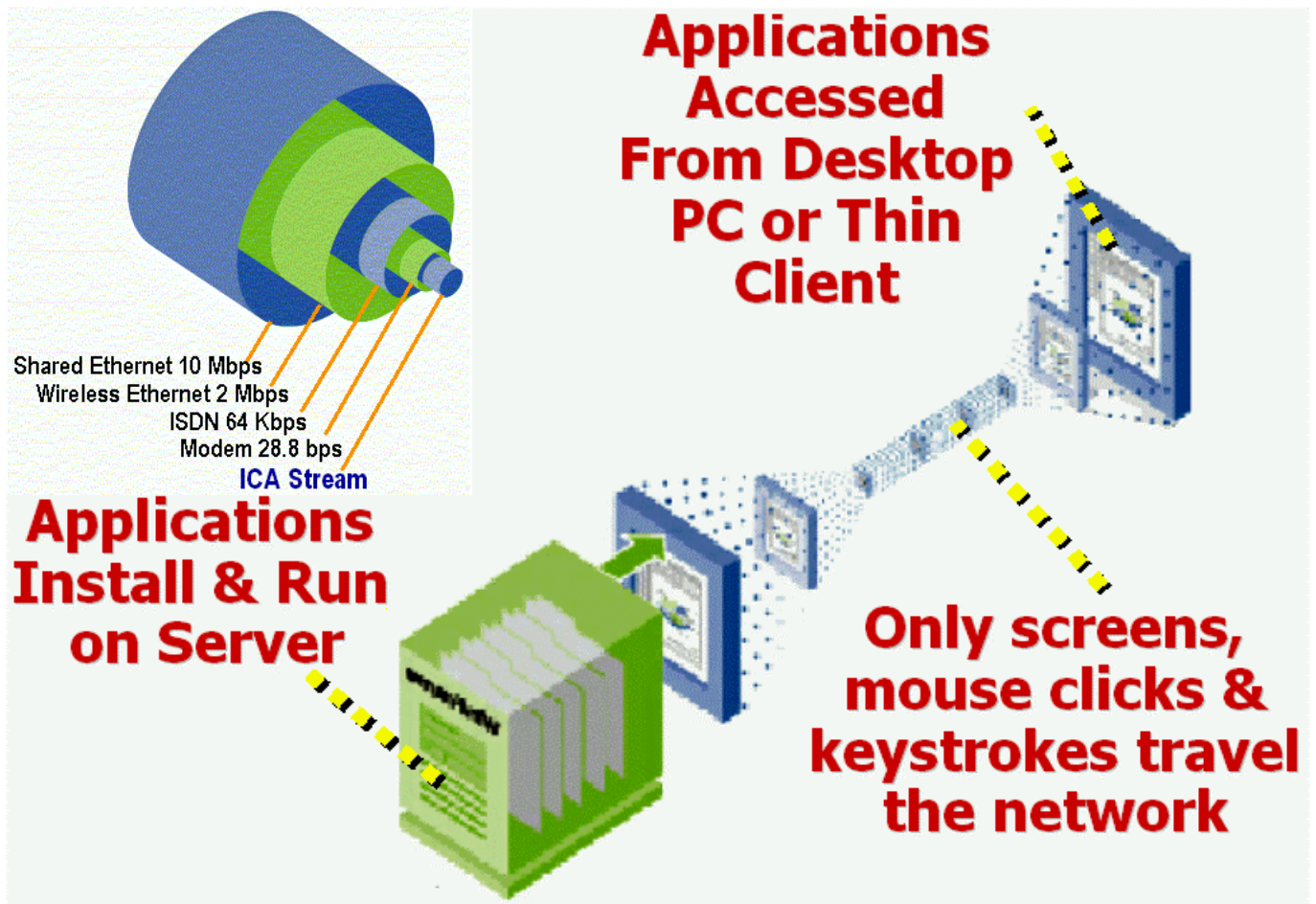
With the continued popularity of the UNIX platform, organizations are anxious to provide broader access to UNIX and Java applications, from any device, without requiring an extra software tier or terminal emulation. Citrix MetaFrame for UNIX Operating Systems delivers these applications to users anywhere, via any connection or device - thin-client terminal to handheld. With MetaFrame application server software, users also gain the benefits of improved performance over low-bandwidth connections and tighter security. Further, when MetaFrame for Windows 2000 Servers and MetaFrame for UNIX Operating Systems are used together, they can deliver virtually any application to any device.

General introduction: ICA

Citrix's Independent Computing Architecture (ICA(r)) technology provides the foundation for turning any client device -- thin or fat -- into the ultimate thin client. For this reason, ICA has become a de facto industry standard for delivering corporate applications across the broadest variety of desktop platforms and networks.

On the server, ICA has the unique ability to separate application logic from the user interface. On the client, users see and work with the application's interface, but 100% of the application executes on the server.

The ICA protocol sends only keystrokes, mouse clicks and screen updates across the network. Applications consume just a fraction of the network bandwidth usually required.



This efficiency enables the latest, most powerful UNIX, Windows and Java applications to be accessed with exceptional performance from existing PCs, Windows-based terminals, network computers and a new generation of business and personal information appliances.

Deploying applications using MetaFrame for UNIX Operating Systems

MetaFrame for UNIX Operating Systems allows UNIX applications to be deployed to client devices using ICA. Applications or desktops are “published” using configuration tools provided, and made available to clients. Any application that delivers its user interface using the X Window System (version X11R6.3) can be published in this way. This includes X11 applications, Java applications running in a UNIX JVM, and text applications including terminal emulators. Desktop environments such as CDE and OpenWindows can also be published, allowing users access to a complete UNIX desktop via ICA.

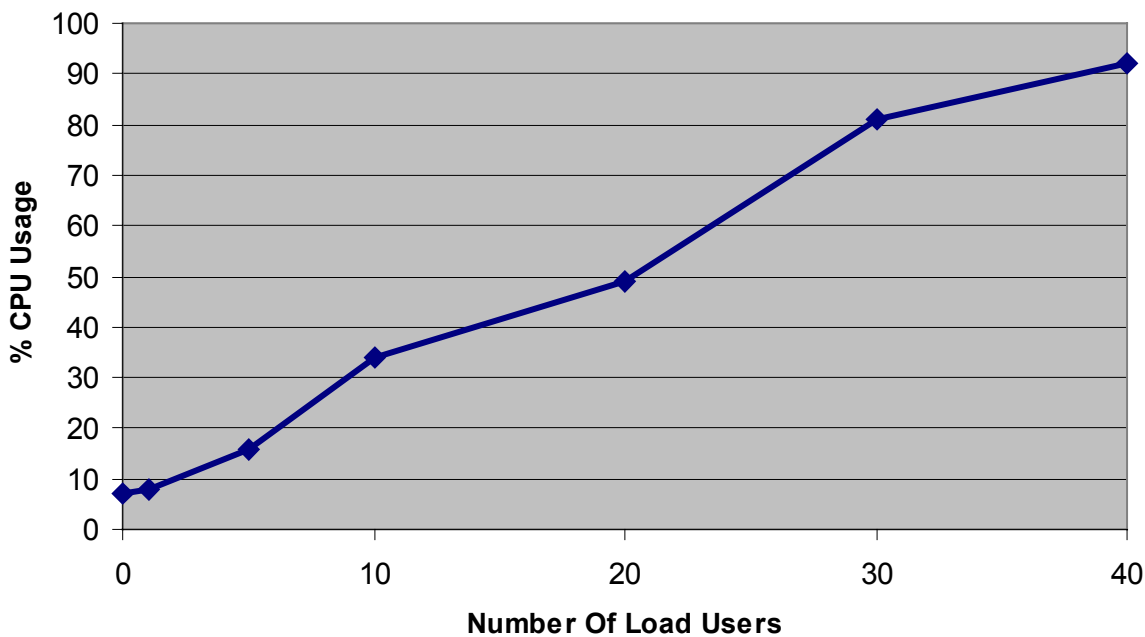
How many users per server?

One of the issues that needs to be addressed when deploying applications with MetaFrame for UNIX Operating Systems is the number of users that can be supported per server. This depends largely on the applications being published, as well as the specifications of the server. Some applications require more memory than others, and the behaviour of different applications at different times will govern the amount of CPU load. For these reasons, this white paper can only give a very rough guide to the number of users that can be supported by a particular server.

The graph below was generated using a benchmark consisting of a scripted suite of business applications running in the Common Desktop Environment.

The server was a Sun Ultra60 with 2 UltraSPARC 360MHz CPUs running Solaris 7 with 1GB RAM and the ICA clients were running on a range of Win32-based machines.

MetaFrame for UNIX Server CPU load vs. User Load



A server is usually considered to be running at optimal loading when CPU load is around 80-90%. Hence, these results suggest that around 30-40 users can be supported in this server configuration, or 15-20 per UltraSPARC 360MHz CPU.

Analysis of memory usage suggests that each user requires around 16-24 MB of RAM, although this figure is much lower (12-16MB) when a Window Manager is not used.

These figures assume that there is no significant page-swapping by applications at these levels - in other words, that the applications are residing almost completely in RAM. More information on memory use on Solaris systems can be found at <http://www.sun.com/sun-on-net/>.

Due to the systems architecture of most UNIX Operating Systems, it is often possible to increase the number of users supported by a single server significantly by increasing the amount of memory (RAM) available on the system, and adding more CPUs -

creating a multi-processor system. Such hardware systems are well-supported by most UNIX Operating Systems, and MetaFrame for UNIX Operating Systems allows applications running in these environments to make the most of this scalability.

How ICA differs from the X Protocol

Although both ICA and the X Protocol allow applications to be accessed from a remote client, there are some significant differences between the two. For the purpose of this description, the term "server" is used to describe the system on which the application is running, and "client" the system on which the display is viewed, keystrokes entered, mouse movements made, etc...

ICA clients are available for a vast number of different devices and Operating Systems, including all the major UNIX variants, Windows, Windows CE, DOS, Macintosh, EPOC, Java and a large variety of terminal devices. There are currently over 15 million ICA clients in use worldwide.

ICA is also Operating System neutral, which means that applications running on Windows systems and UNIX systems can both be accessed from the same ICA client - organisations can publish Windows applications together with UNIX applications, and their users can access both at the same time, even cutting and pasting text between the two.

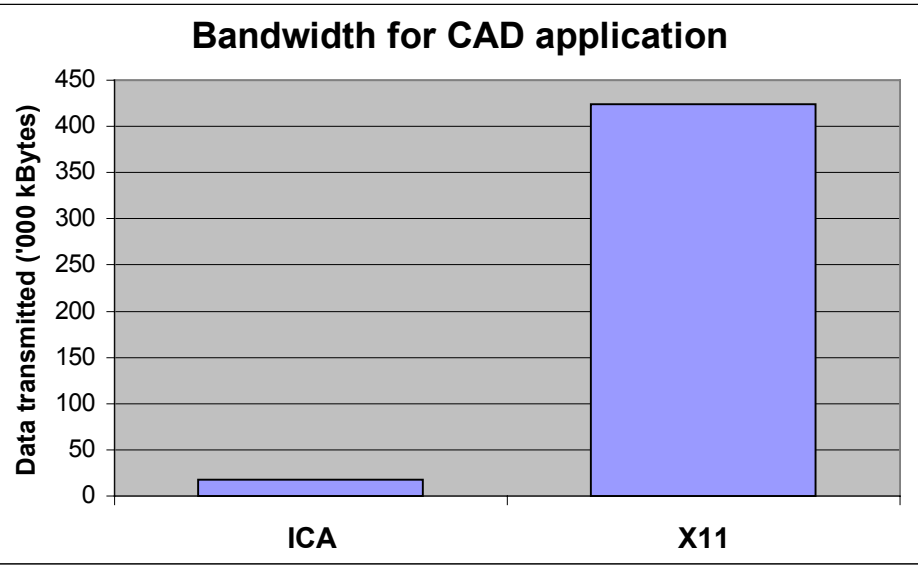
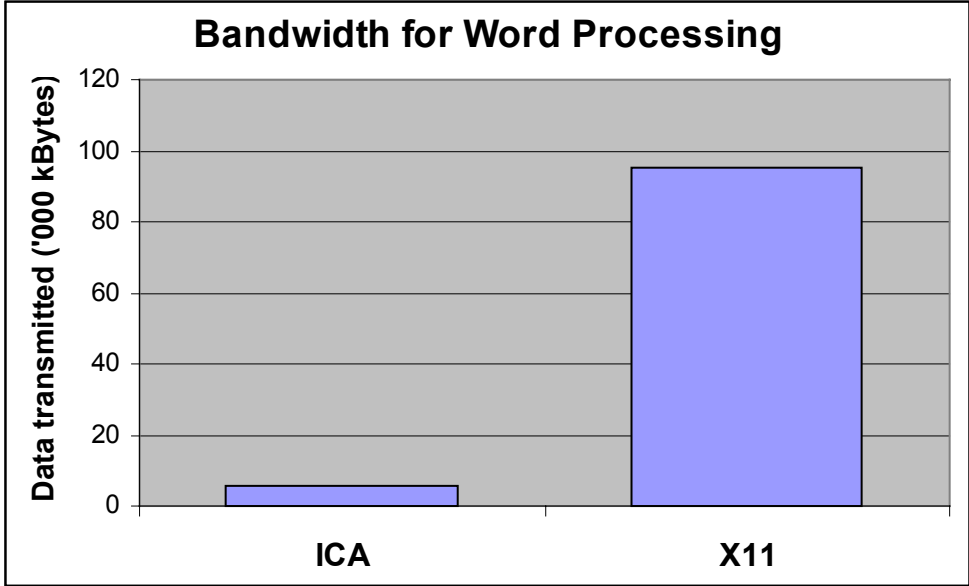
Another difference is that while the X protocol was designed to be used in deployments over local area networks (LANs), where available bandwidth is typically quite high, ICA is designed to be bandwidth-independent, meaning that it operates as well over a dial-up connection as over a LAN. SpeedScreen 2 technology, developed by Citrix, provides compression of the data stream between client and server yet further than the basic protocol. The X protocol, on the other hand, requires significantly more bandwidth, and this means that deploying applications over a heterogeneous networks can be very difficult, if not impossible. More information on bandwidth utilisation is available in the section "Bandwidth utilisation" below.

Finally, the ICA architecture allows the ICA protocol to be extended to add capabilities above and beyond display, mouse and keyboard support. "Virtual channels" can be added to ICA to allow other data to be carried, adding extra capabilities. It is within this virtual channel architecture that MetaFrame for UNIX Operating Systems' provides printing capabilities and the cut and paste functionality.

Bandwidth utilisation – How much bandwidth does it use?

One of the most important aspects of deploying applications over heterogeneous networks is the bandwidth utilisation of the protocol being used to pass the data, and ICA has a protocol that is tuned to make very efficient use of bandwidth. This section gives an indication of typical levels of bandwidth used by ICA, and compares this with that used by the X11 protocol.

In tests performed to measure the network bandwidth generated by running an application using ICA compared to X11 two different applications were tested – a CAD application and a Word Processor - with a variety of behaviours and types of content (text, images, etc.). The tests were conducted on a Sun Ultra60 running Solaris 7 over a 100Mbps Ethernet LAN.



As can be seen from the results, the average bandwidth required by X11 was between 15 and 25 times greater than the ICA generated by MetaFrame for UNIX. Such figures are not very surprising given that most X protocol implementations tend to aim for speed, and attempt to tune the implementation for fast execution at the expense of the amount of data sent, thus driving the bandwidth requirements up. However, the tests also showed that even given the significantly lower bandwidth requirements of ICA over the X protocol implementations, the speed taken to perform the tests was usually faster using ICA than either PC-based X emulators or UNIX-based X11 clients.

Finally, in response to the question “What is the thinnest connection I can use?” On connections as thin as a modem link, the bandwidth available is directly related to the performance experienced by the end-user. However, experience has shown that even on a 28.8k modem many applications will work with acceptable levels of performance using ICA technology. It really is that thin!



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