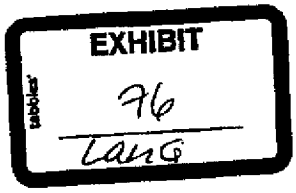
burst.com

COPY

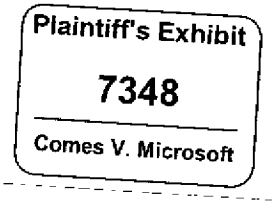


BurstSim

Release 2.0

BURSTWARE® SIMULATOR

USER GUIDE



Overview

This application facilitates comparisons between the Burstware and real-time streaming approaches to the delivery multi-media payloads over a network, across a range of server, network, and player configurations, load profiles and media content. Leaving real-time streaming aside, the application can also be employed as an aid to the deployment of Burstware within servers on networks: a proposed configuration is subjected to range of anticipated stimuli, the response is observed, the configuration adjusted accordingly, and so forth repeatedly until a satisfactory result is obtained.

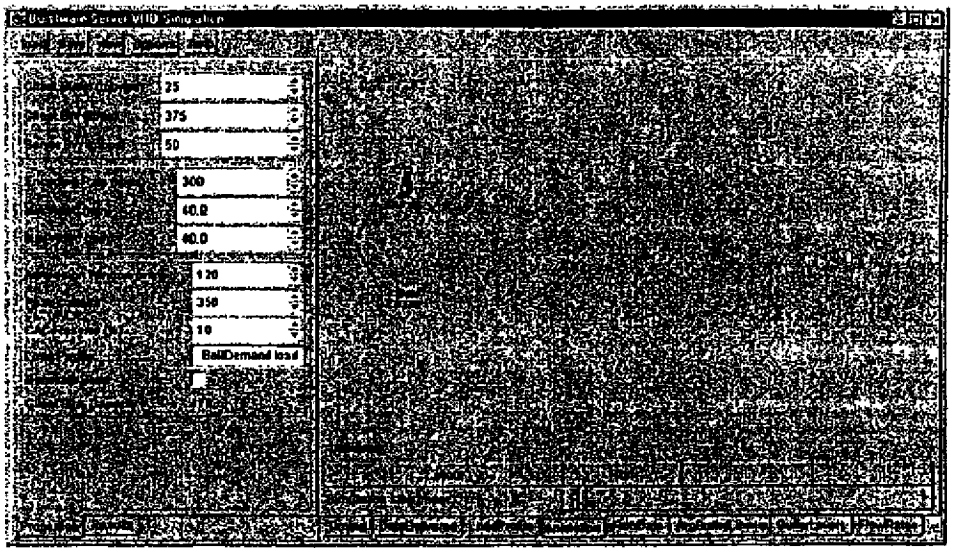
BurstSim can simulate the performance of a server and its clients in one of two scenarios:

1) Video-on-demand (VOD). In this scenario, stochastically generated clients endowed with a player approach a server with a request to view a piece of content of stochastically generated duration.

2) Live Event. In this scenario, a live performance of known duration begins at the start of the simulation. Stochastically generated clients present themselves for service during the specified admission window, which may extend beyond the live event.

User Interface

The Graphical User Interface is depicted below. As shown it is organized around two sets of tabbed panels. To the left one finds information presented in textual form, whereas to the right the focus is on graphical presentation. On top a menu bar proposes a number of pull-down menu options by means of which the scenario is selected, runs can be saved and restored, help can be obtained, and the presentation of data effected.



Textual versus Visual Panels

Panel Overview

The tabbed panels can be characterized as follows

Properties Panel	Provides entry fields for each of the parameters of a simulation run. Several of these parameters depend on the scenario selected: VOD versus Live.
Results Panel	Conveys the summary results of the simulation run
Animation Panel	Provides simulation controls, depicts the state of a simulation while running, and when the simulation ends, indicates the maximum number of players serviced by Burstware and real-time streaming at any one time.
Data Delivered Panel	Depicts, as a function of time, the aggregate content flow rates from server to all players under Burstware and real-time streaming.
Run Data Panel	Provides a detailed accounting of the disposition of all incoming service requests under Burstware and real-time streaming, for analytic or diagnostic purposes.
Timing Panel	Displays of a time line showing every instance of call rejection by Burstware or real-time streaming.
Load Profile Panels	Displays the variations in the mean arrival rate of incoming service requests, or, alternatively, cumulative service requests

	as a function of time, as explained below
Average Buffer Level Graph	Graph display of the average buffer level for every player, computed at the point when the server has completed its delivery. Buffer levels are represented in minutes of play time.
Buffer Level Panel	Plots the incremental[1] player-side buffer level for every *monitored session*. As many as nine client sessions may be monitored. Sessions must be selected before a run by way of their associated session number (see pull-down menu *view. session monitor)*
Flow Rate Diagram	Plots the content flow rate from server to player, for every monitored session, in relation to the flow rate for real-time streaming (which equals the encoding rate).

Menu Tree Overview

The menu hierarchy is structured as follows:

Menu bar label	Pull down label	Action description
load		
	saved run	Restores the properties and also the numeric and graphical results of a previously saved simulation run. Causes file dialog box to appear. By convention, property and result files bear the *.run* extension.
	Properties	As above, excepting the results of a previous run if available. Causes file dialog box to appear.
save		
	Run results	Causes all properties and, as available, results associated with a completed simulation run to be saved for later retrieval. Causes file dialog box to appear.
	click log	Causes the sequence of incoming requests that served as stimuli to the past simulation

[1] Buffer levels are incremental to the initial buffer levels established during the initial "buffering period" prior to the start of play, which we assume to be equivalent for streaming and bursting. In practice the start-up latency for Burstware can be appreciably shorter for bursting than for streaming owing to the steady accumulation of content in player-side buffers under the former.

		run to be saved as a click log load profile.
view		
	exceptions only (toggle)	This checkbox option relates to the Run Data Panel. If selected, the table will display data that relates only to service requests that were handled differently by Burstware and real-time streaming. Otherwise, the table presents all available data.
	update properties	Forces a recalculation of dependent property values, which are then presented.
	session monitor	Causes activation of a dialog box used to manage the list of monitored sessions. Sessions are identified by way of their session numbers, which may be obtained from a fully expanded data panel (see menu option *view.exceptions only*)
	notes	Notes about simulation run
Options		
	live simulation (toggle)	The setting of this checkbox determines which of the two alternative scenarios is selected: VOD versus Live Event. The default scenario is VOD.
help		
	manual	Activates designated browser open to the help document.
	about	Provides miscellaneous information about the software (e.g. version)

Textual Panels

Two textual panels are provided: one to specify the properties of a run, the other to present the results.

Properties Panel

Data can be specified for each field, typically by selecting a value from a list of choices presented in a pull-down selection list, spin box or check box.

A simulation is driven by incoming client requests as per the characteristics of the given *load profile*. A load profile can be specified in one of two ways:

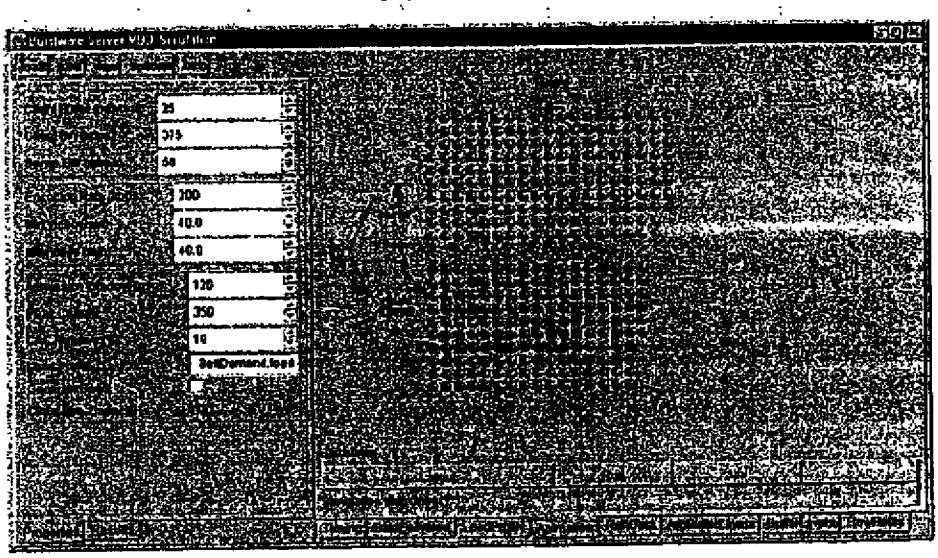
Historically, according to a pattern of incoming client requests observed in the past and captured in a *click log* (applies to VOD scenario only).

Stochastically, according to a random process characterized by a) an exponential distribution of arrival times, b) time-varying intensity as specified by a load profile curve, c) a seed value which can either be frozen, or allowed to vary so as never to generate the same data twice.

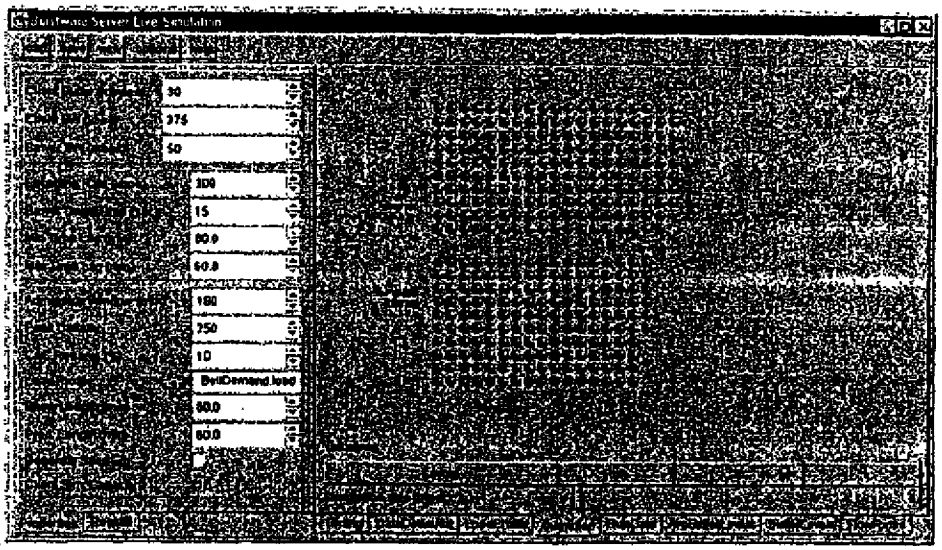
The nature of the stimuli – historic or stochastic — is inferred from the format of the load profile file, which must either be designated by the user using the associated entry field, or recovered as a characteristic of a previously saved simulation run now subject to replay. As will be shown, input to a number of fields is disabled in the event of a historical data, either because they do not apply, or because they serve only to display property values that can be inferred from the given historic *click log*.

There are two separate properties panels, one for VOD and the other for Live events, as depicted below.

VOD properties Panel



Live properties Panel



The data entry fields are the following:

Property	Units	Scenario VOD/Live/ all	Meaning
Client Buffer	mbytes	all	Size of media buffer in the client's player.
Client BW	kbps	all	Bandwidth of the data pipe linking the Burstware server to the client's player.
Server BW	mbps	all	Maximum aggregate rate at which the media server can deliver data to all clients.
Encoding rate	kbps	all	Media play (encoding) rate. This value equals the average real-time streaming rate.
CAC margin	%	all	Percentage of server BW set aside for greater than real-time delivery of content among active sessions. A value of zero may cause bursting to degenerate into streaming under heavy load. A positive value (e.g. 10%) ensures content accumulation within player buffers, thereby improving QOS.
Min. Video	minutes	VOD	Play time of the shortest video. In the event of historic data, the value is inferred from the click log.
Max Video	minutes	VOD	Play time of the longest video. In the event of historic data, the value is inferred from the click log. In the stochastic case, the

			video plays time for any given service request is generated randomly according to a uniform probability distribution between the min. and max values.
Admission Window	minutes	all	The time period over which requests for video delivery/live event participation are submitted by the simulator[2]. This value is inferred from the click log when applicable.
Peak (resp. average) Calls / hour	qty calls / hour	all	The peak (resp. average) arrival rate of calls for stochastic (resp. historic) stimuli. In the former case, a stochastic process with an exponential distribution that generates calls at the mean rate specified here generates incoming video requests (calls). The percentage of the calls that are retained at any given time is characterized by the load profile curve. In the event historic stimuli, the value is inferred from the click log.
Load Profile	<filename>.load	all	Designates the file containing a description of the load profile over time, either as a percent of peak call arrival rate (stochastic stimuli), or as a click log. Double clicking on the entry field causes a dialog box to appear. The name of the selected file is confirmed in the text field. The load profile is rendered visually in the Load Profile panel (see below). The length of the time axis is obtained from the Admission window parameter.
Generate Seed	yes / no(default)	all	The various stochastic processes used throughout the simulation are not reproducible across runs unless this option is disabled. Does not apply to historic stimuli. Normally disabled when sessions are being monitored.
Client simulation Capacity	qty	all	Computed value specifying the maximum number of clients that the simulation can handle. The following formula is used: (ServerBW/ Encoding Rate) *2.0 To force a calculation of this value when either factor is modified, activate pull down menu *option view.update properties*.

[2] For Live events, this value should equal the show length unless the min & max lags are non-zero.

Server Dwell Time	Seconds	Live	Transport delay in server between encoding and transport of content to clients. Under Burstware the delayed content is assumed to be available for early delivery by the server.
Show length	Minutes	Live	Duration of live event.
Predicted Show Length	Minutes	Live	Reserved for future use.
Minimum Lag Time	Minutes	Live	A viewer's time lag relative to the live event. When set to zero, the users watches the live event with no delay beyond the dwell time. When set to the event (show) length, the user watches the "live" event from the beginning[3].
Maximum Lag Time	Minutes	Live	As above. The time lag for any given service request (session) is generated randomly according to a uniform probability distribution between the min. and max values. To disable random selection set the min & max values to the desired value.

Results Panel

The result panel is depicted below. This panel is automatically brought forward once a simulation run is initiated by pressing the *Run* button on the Animation Panel, which is also shown. The results posted for Burstware and real-time streaming alike, to their respective sub-panels, are the following:

Result	Units	Meaning
Viewer Requests	integer	.Total number of VOD/Live requests generated during admission window. (= viewers accepted + viewers rejected)
Viewers Accepted	integer	Number of sessions successfully completed
Viewers Rejected	integer	Number of calls that were rejected due to insufficient capacity.

[3] Such a viewing lag is possible because the live stream is being archived on the fly within the server.

Max Concurrent Viewers	integer	Maximum number of sessions in progress at any one time. Under Burstware this count includes those players for which all content has already been delivered to local media buffers, from which content is drawn till empty. Such a situation can occur only momentarily under real-time streaming.
Content Delivered	Mbytes	The total amount of media content delivered from server to clients over the run.

The results obtained for Burstware and real-time streaming are compared and then posted to the sub-panel entitled "Gains for Burstware", as follows

Result	Units	Meaning
Total Viewers	%	Percentage increases in the quantity of video requests accepted. Equals (Burstware (Videos Delivered) - Streaming (Videos Delivered))* 100. / Streaming(Videos Delivered)
Concurrent Viewers	%	Percentage increase in the quantity of video viewed simultaneously. Equals (Burstware (Max Concurrent Viewers) - Streaming (Max Concurrent Viewers))* 100. / Streaming(Max Concurrent Viewers)
Mean of average buffer level	Seconds of play time	The mean value of the sample of average session buffer levels[4] resulting from the past run (i.e., those graphed over time in the Average Buffer Level panel. *This value together with the next two can serve as rough measures of QOS, as they reflect the degree to which sessions are buffered against network congestion events that induce delays in delivery, or data loss & subsequent recovery.*
Standard deviation of average buffer levels	Seconds of play time	The standard deviation of the sample of average session buffer levels resulting from the past run (i.e., those graphed over time in the Average Buffer Level panel). This value reflects the dispersion of average session buffer levels around their mean (above).
Minimum average	Seconds of	The average buffer level of the session the player buffer

[4] Specifically, this value equals the average level of content within the media buffer of a sessions' player, during the time interval when server and player are connected.

buffer level	play time	of which came closest to running dry, and thus most vulnerable to interruption in the event of network disturbances.

Graphical Panels

Animation Panel

This panel has been depicted twice already in two previous figures, as befits its importance. It is endowed with a number of controls, and also provides animation feedback to the user while the simulation proceeds.

Simulation Controls

The available controls are these:

Layout	Forces a recalculation of all dependent property values and a reset of all result display, both textual and graphical. This button is pushed implicitly when Run is pushed.
Run	Causes the simulation activity to commence, and advance at a rate given by the Simulation Step interval.
Pause	Causes the simulation to pause until resumed.
Stop/Restart	Causes the simulation to stop if running or resume if paused. A simulation once stopped cannot be resumed.
Simulation Step	Adjusting the slide bar specifies this interval. It determines the time interval of rest between simulation steps, specified in milliseconds. The default step interval of one millisecond is also the minimum allowed. The maximum allowed is 1000 milliseconds (i.e. one second). The step value can be adjusted as needed during a run to observe discrete simulation events of interest or concern in slow motion.

Animation Feedback

Once a simulation is started, the elapsed simulation time *in minutes* is updated at the start of every simulation step.

The main animation panel depicts a server sourcing an identical stream of video requests to a Burstware server and a real-time streaming server. As each server accepts a request, a channel is allocated to a viewer, and content begins to flow. A ball (the size of which will vary according to the computed simulation capacity) that is color coded as follows represents viewers:

red	A viewer that is currently receiving content over the network and thus consuming network capacity.
yellow	A Burstware viewer that has received all of its content (thereby unburdening the network) yet continues to view this content, which is now drawn out of the local media buffer. Under real-time streaming the yellow interval would make only the briefest appearance, for the viewing

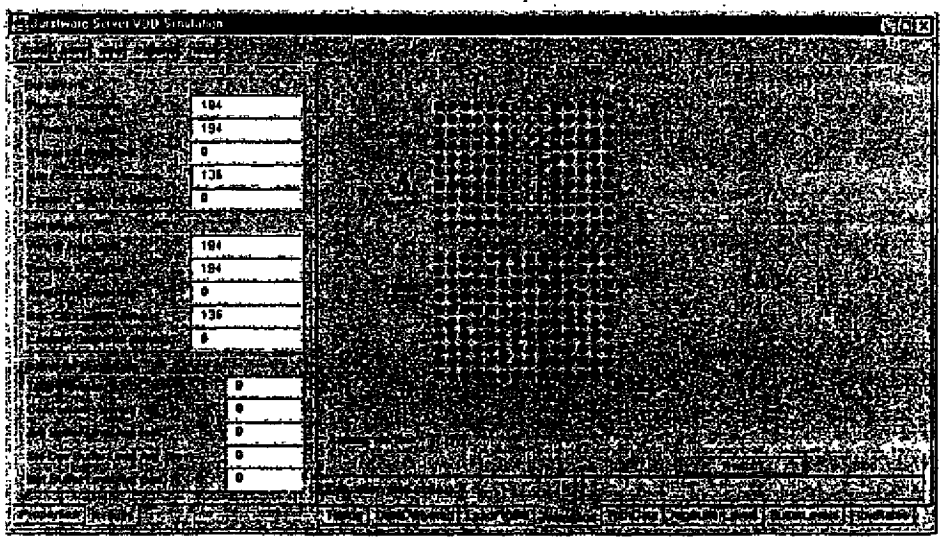
interval is always equal to the delivery interval, shifted in time by a few seconds at most[5].

green A green ball can be thought of as representing a viewer that has previously viewed content and is available to view more.

At the conclusion of a simulation run the number of green balls remaining is reflective of the total size of the community of viewers that participated simultaneously at some point in time.

The figure below depicts a simulation frozen in mid-stream, which includes a number of Burstware users (shown in yellow) that are viewing videos without burdening the network.

Animation Panel frozen in mid-run

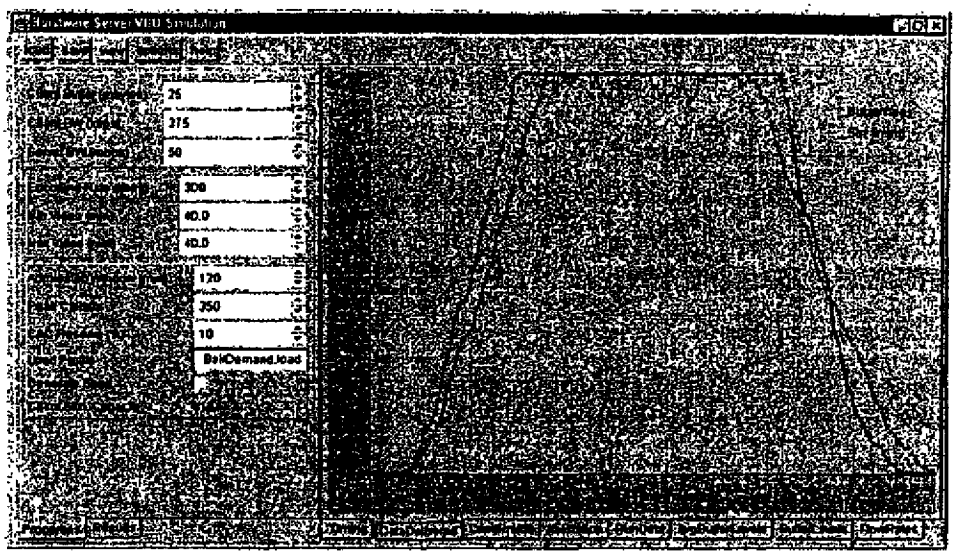


Data Delivered Panel

This panel, and example of which is depicted below, presents a graph of aggregate content flow rate for both Burstware and Streaming over the course of a simulation run.

[5] Our present simulation does not model the effects of buffer size for real-time streaming. It can however be shown that the results posted to the result panel are not affected by this omission.

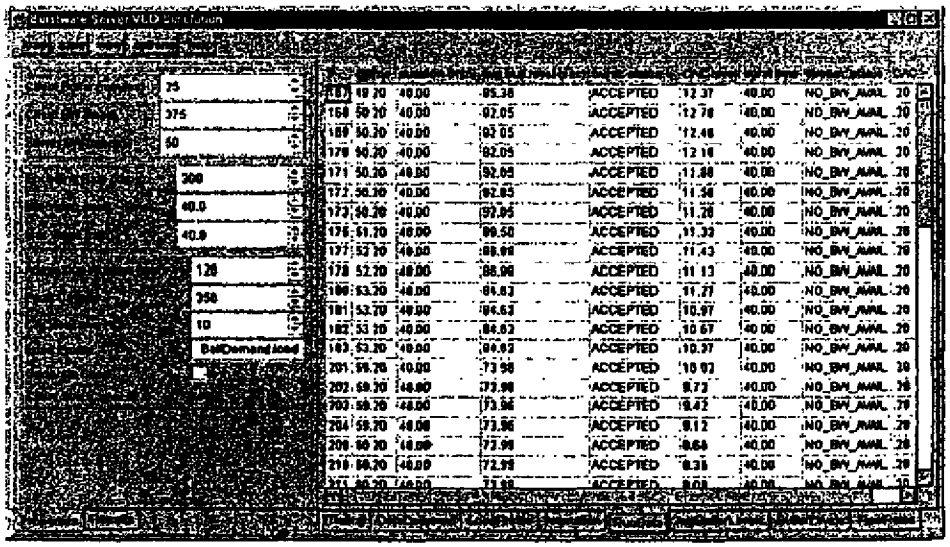
Data Delivered Panel



Run Data Panel

In the result panel, under Streaming, the number of requests subject to rejection is indicated to be 21. Details on these rejected video requests may be found in the Run Data Panel depicted below, which includes information bearing on only those requests that were subject to rejected under Burstware or Streaming.

Minimal Run Data Panel

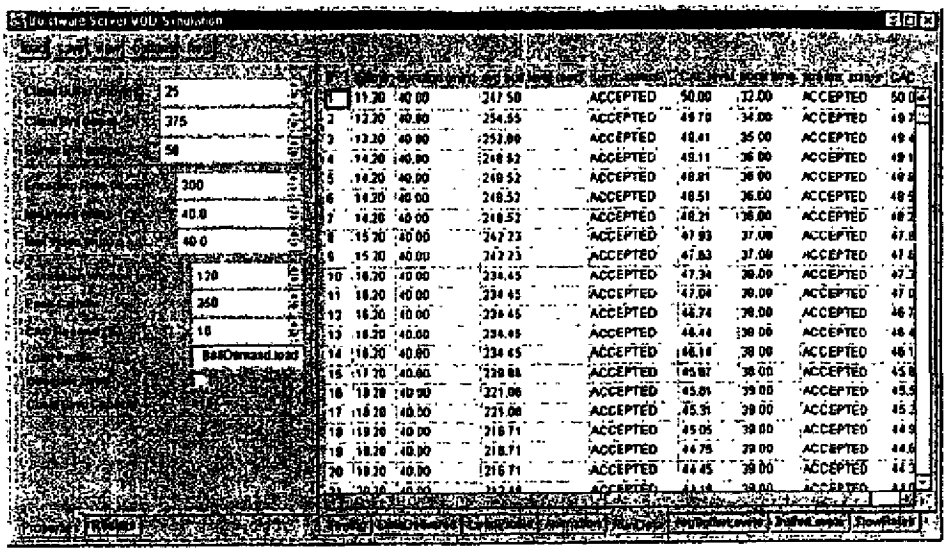


After toggling the check *box view.exceptions only to false*, a full accounting of all video requests appears in this panel, as shown in the figure that follows. The columns making up both tables contain the following information:

label	units	Description
#	integer	Monotonically increasing sequence number, starting at 1, that uniquely identifies every incoming video request.
@time	seconds	Simulation time at which the video request was presented to the servers for disposition.
duration	minutes	Video play time at the designated play rate
Average buffer level	Seconds of play time	The average buffer level within the player's media buffer while player and server are connected.
Burst Status	One of : ACCEPTED NO_BW_AVAIL NO_CH_AVAIL	Disposition of Burstware server: call accepted, or rejected owing to inadequate server capacity or simulation capacity.
Bursware CAC level	mbps	Available network reserve capacity[6] according to the Call Acceptance Control (CAC) and optimal flow modulation algorithms employed by Burstware (patent pending). This value should exceed the play rate or the video request will be rejected (NO_BW_AVAIL).
Burst time	minutes	The number of minutes needed by Burstware to deliver all video content from the server to the play station. The equivalent time for streaming must always equal the media play length.
Streaming Status	One of : ACCEPTED NO_BW_AVAIL NO_CH_AVAIL	Disposition of real-time Streaming server: call accepted, or rejected owing to inadequate server capacity or simulation capacity.
Streaming CAC level	mbps	Available network capacity. This value should exceed the play rate or the video request will be rejected (NO_BW_AVAIL).

[6] Under Burstware a network may be fully utilized yet capable of taking on another client without any compromise in service, by throttling back on the rate of content delivery to existing clients.

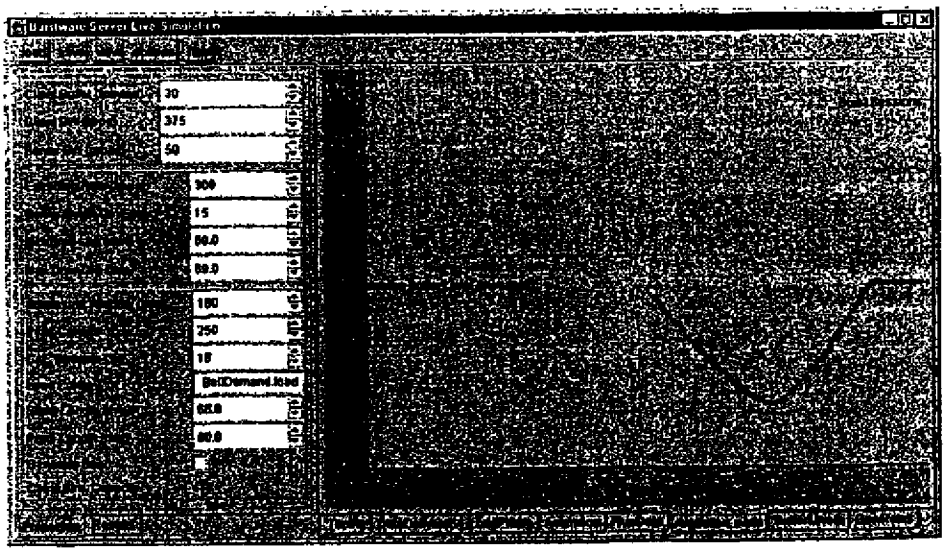
Fully expanded Run Data Panel



Average Buffer Level Graph

This panel plots the average buffer level for each burst session over time. Average Buffer levels are plotted according to the termination time of their associated sessions. In an over-provisioned server, the graph is a straight horizontal line.

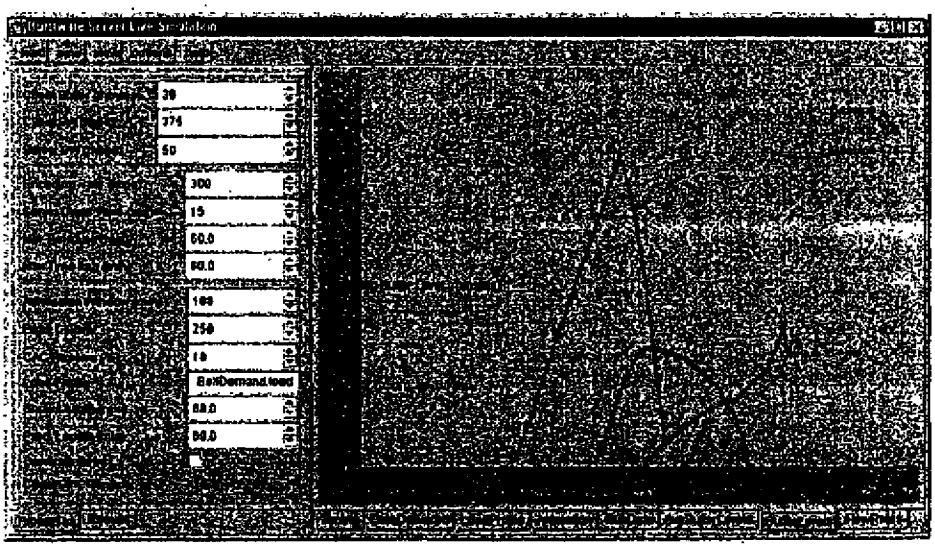
Average buffer level graph panel for under-provisioned server



Buffer Level Panel

This panel shows the media buffer level over time for individual *monitored sessions*. The buffer level graph provides deeper insight into buffer level dynamics than does the average value posted to the (fully expanded) run data panel. In the example below, one buffer level trajectory begins and ends at zero, indicative of a session for which data was delivered *just-in-time*, during the period when the load on the server is heaviest. In contrast, the remaining trajectories appear to terminate in mid-flight, indicative of early delivery of all content to players during the periods of rising and ebbing traffic flanking the period of peak load. All trajectories reveal healthy levels of buffering consistent with use of a CAC-margin of 10%.

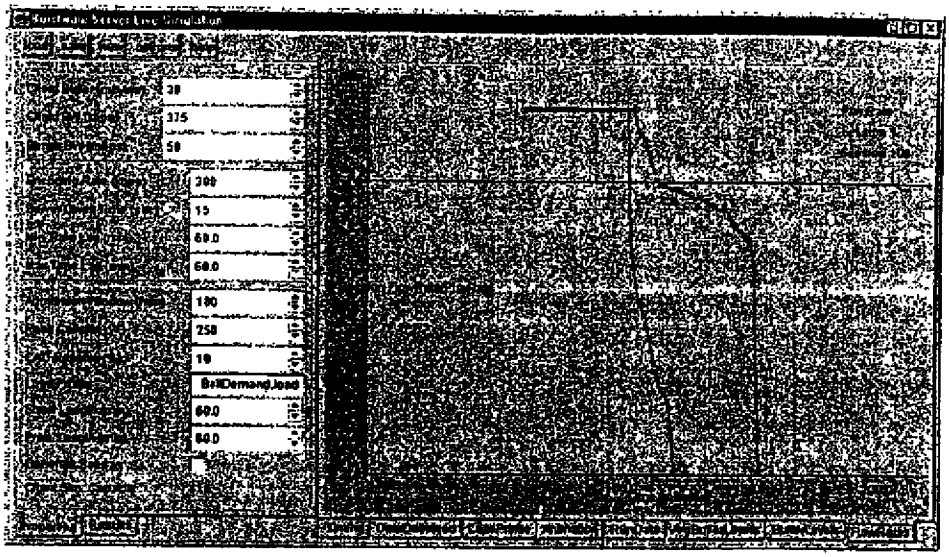
BufferLevel Panel.



Flow Rate Diagram

This panel is a companion to the previous one, depicting the content flow rate from server to client for monitored sessions, if any.

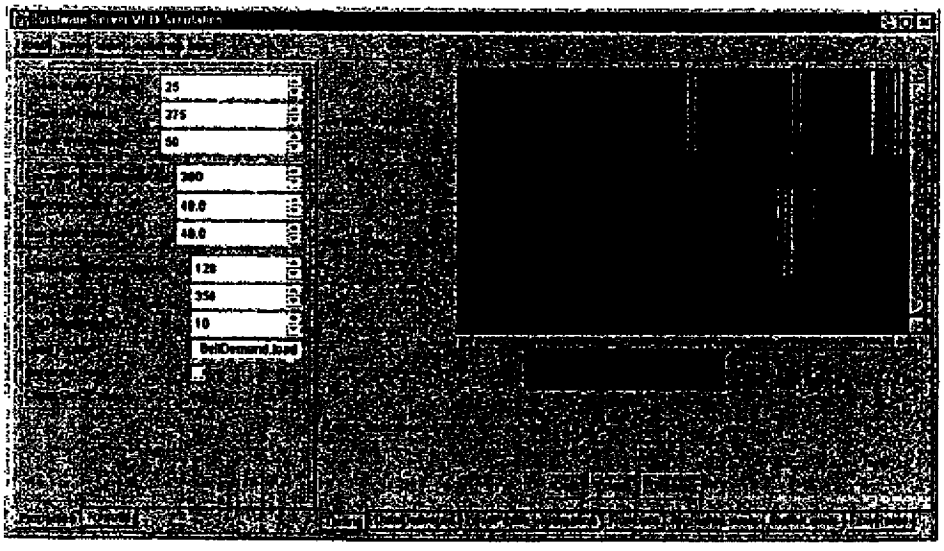
Flow Rate Panel



Timing Panel

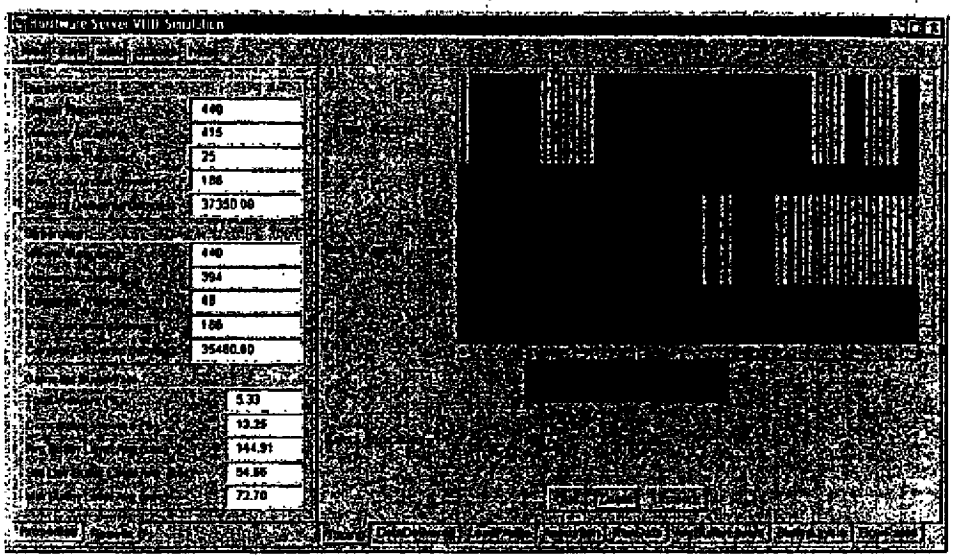
This panel can be used obtain a quick look at when and where videos were rejected over time under Bustware and Streaming. In this diagram a vertical pale blue line represents every instance of rejection. Thus, in the panel depicted below, we can readily see that real-time streaming rejected videos toward the end of the simulation run, whereas Burstware rejected others toward the middle.

Timing Diagram



A more detailed look at the rejection events can be had by pressing on the zoom button, resulting in a display such as the one below:

Timing Diagram After Zoom



Load Profile Panels

This panel differs from the previous results-oriented graphical panels as it is intended to convey the character of the event stimuli used to drive the simulation.

Stochastic Load Profile

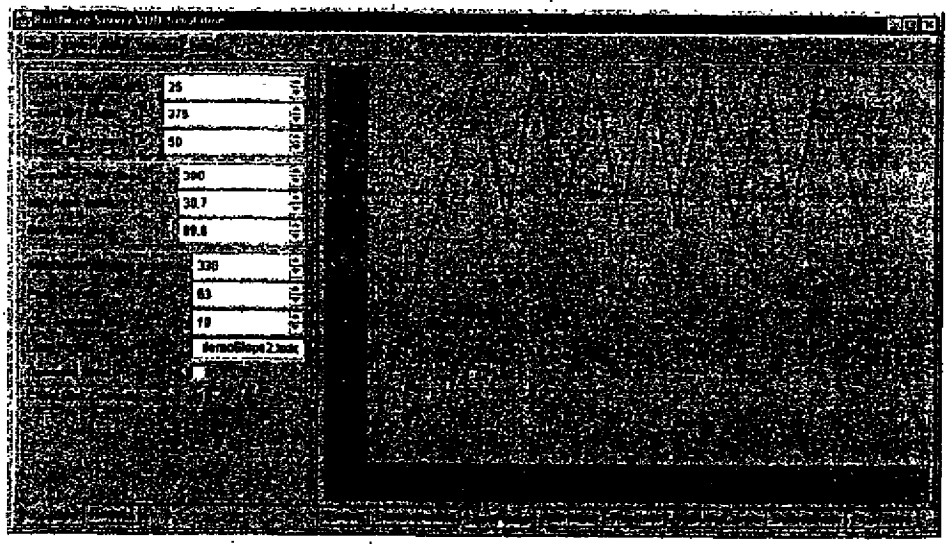
A typical stochastic load profile is depicted below. The serrated edges are intended to vary the mean arrival rate of incoming service requests between 60 % and 100% of the mean arrival rate specified in the properties panel (100 calls per hour).

This graph was obtained by parsing the given load profile text file, the contents of which are these:

```
15
0       0.0
60      100.0
75      60.0
90      100.0
105     60.0
120     100.0
135     60.0
150     100.0
165     60.0
180     100.0
190     60.0
210     100.0
220     60.0
240     100.0
300     0.0
```

According to this line-oriented format the first line specifies the total number of lines that follow. Each of these, which must be provided in temporal order, specifies an ordered pair of (percent, time) values separated by white spaces. As can be seen, a straight line links consecutive points on the graph.

Load Profile Panel



Historical Load Profile via a Click Log

By driving a specific network configuration with historical data gathered over time from an existing user community and installation, one can gain an understanding of how an alternative network configuration would have responded if presented with the same load.

Historical data must be encoded as a click log that is formatted in much the same way as stochastic load profiles. Specifically, the first line must include a line count followed by the key word "click", as in

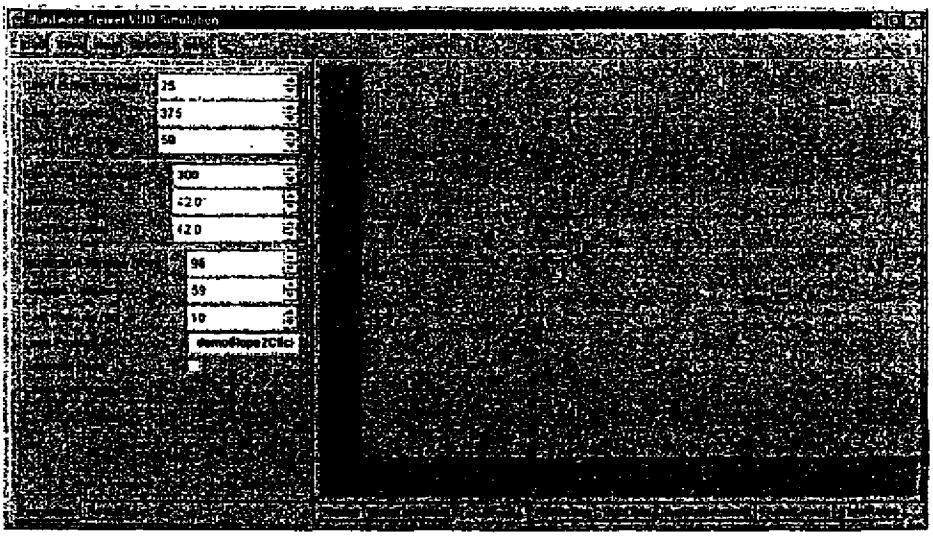
15 click log

The 15 lines that follow must each supply an ordered pair of (arrival Time, duration) values expressed in minutes and separated by white space. For instance

10.2 65.3

The load profile panel parses this file, and posts a graph of the cumulative count of incoming video requests over the simulation interval spanned by the click log arrival times, extended by the duration of the longest video. Such a graph is shown below. Also shown in this figure are a number of disabled input fields of the properties panel, some of which now display values inferred from the contents of click log.

Load Profile Resulting from Historic Data



Properties File

When launched the BurstSim simulator parses the content of properties file *burstSim.properties* which must be located in the current sub-directory

A number of properties have been defined to date, as follows:

property	example	intent

burstsim.base	burstsim.base=c:/ivt/burst_sim/	Specifies the base directory for burstSim
burstsim.default.run	burstsim.default.run=./profiles/a1DemoHighGain.run	Specifies the name of the stored simulation run file to be loaded automatically when the application starts
burstsim.browser	burstsim.browser=c:/program files/netscape/communicator/program/netscape.exe	Specifies the HTML browser to be used to browse the manual.
burstsim.manual	burstsim.manual=./doc/manual.html	Specifies the name and placement of the HTML file containing the manual.
Burstsim.capMultiplier	Burtsim.capMultiplier=2.0	Specifies capacity of simulation, which is given by the number of required streaming channels multiplied by this number.

Run Notes

VodDslLoHeadModGain.run

Both Burstware & streaming register rejects. Available headroom for bursting is modest (375 kbps bandwidth versus 300 kbps content). Consequently the efficiency gains are modest also (at 5%).

Nevertheless, the QOS benefits are impressive. A minimum average reserve in players of 54 seconds should be sufficient to stave off buffer underflows in any but the worst disruptions. Most sessions enjoy healthier reserves still.

Drilling into the worst case session (the middle curve in the bufferLevels panel) we see a healthy convex arc characteristic of burst sessions under heavy load whenever a CAC reserve is provided (10% in this instance).

VodDslLoHeadModGainNoCac.run

Both Burstware & streaming register rejects. Available headroom for bursting is modest (375 kbps bandwidth versus 300 kbps content). Consequently the efficiency gains are modest also (at 6%).

In this instance the CAC margin has been set to zero, resulting in perilously low average buffer levels (see AvgBufferLevels panel) during the period of peak load.

Drilling into a worst case session (curve 278) we see a meandering buffer level trajectory that fails to lift off convincingly. The corresponding flow trajectory hovers around the streaming rate.

Conclusion: a CAC margin is required, or burstware may degenerate into a streaming-like QOS under heavy load.