Ch 12 Online Game Traffic Characterization

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Overview

- Game and player analysis
- Traffic Measurements
- Traffic Characterization

Game Analysis

- First Person Shooter (FPS) – most demanding of all online games
  - Requires very fast response times
  - Server has to maintain dynamic state based on all active user inputs
  - Player updates must be broadcast to all other players in a timely manner to ensure that all participants are seeing the same view of the game

Understanding the flow of FPS Games

- Players login to a game server – client – server architecture
- Number of players that can participate in a game is limited
- Games consist of many maps (3D environments)
- Each map is played for a specific period of time
- Length of play on a particular map and which map is to be played can be determined by the server or the players
- Several “rounds” are played on each map
- Most rounds last only a few minutes – 3 - 5

Game Traffic

- Several sources of traffic:
  - Player actions and coordinate information sent from clients to server
  - Server takes all client inputs, creates a current “view”, i.e., global state, of the game and broadcasts to all clients
  - Interactive text messaging
  - Interactive voice communications
  - Client customizations and textures for different maps

Game Engines for FPS

- Several game engines exist for the development of games.
- Game engines differ in several aspects (physics engine, lighting, shadows, pixel depth, etc.) and that can result in differences in the way in which the server and the clients interact for map distribution and client action updates.

Measurement Set-up

- Single server
- Maximum 22 players
- Trace length: 500 million packets (in and out from server)
- 300+ maps were used
- 16,000+ client sessions – each client averaged 3 sessions per week.

Game Data

- Maps were rotated every 30mins
- Clients stored all the maps
- Rounds were capped at 3mins
- Players that were knocked out had to sit and wait till round was completed.
- Server updates to clients were sent out every 50msecs

Trace Data

Start Time	Apr 11 08:55 2002
Stop Time	Apr 18 14:56 2002
Total Time of Trace	7 d, 6 h, 1 m (626,477 sec)
Maps Played	339
Established Connections	16,030
Unique Clients Establishing	5,886
Attempted Connections	24,004
Unique Clients Attempting	8,207

TABLE I
COUNTER-STRIKE NETWORK TRACE INFORMATION

Total Packets	500,000,000
Total Packets In	273,846,081
Total Packets Out	226,153,919
Mean Packet Size	80.33 bytes
Mean Packet Size In	39.72 bytes
Mean Packet Size Out	129.51 bytes
Mean Bandwidth	883 *kbs*
Mean Bandwidth In	341 *kbs*
Mean Bandwidth Out	542 *kbs*

TABLE II
COUNTER-STRIKE TRACE NETWORK STATISTICS

Server Load – In and Out BW

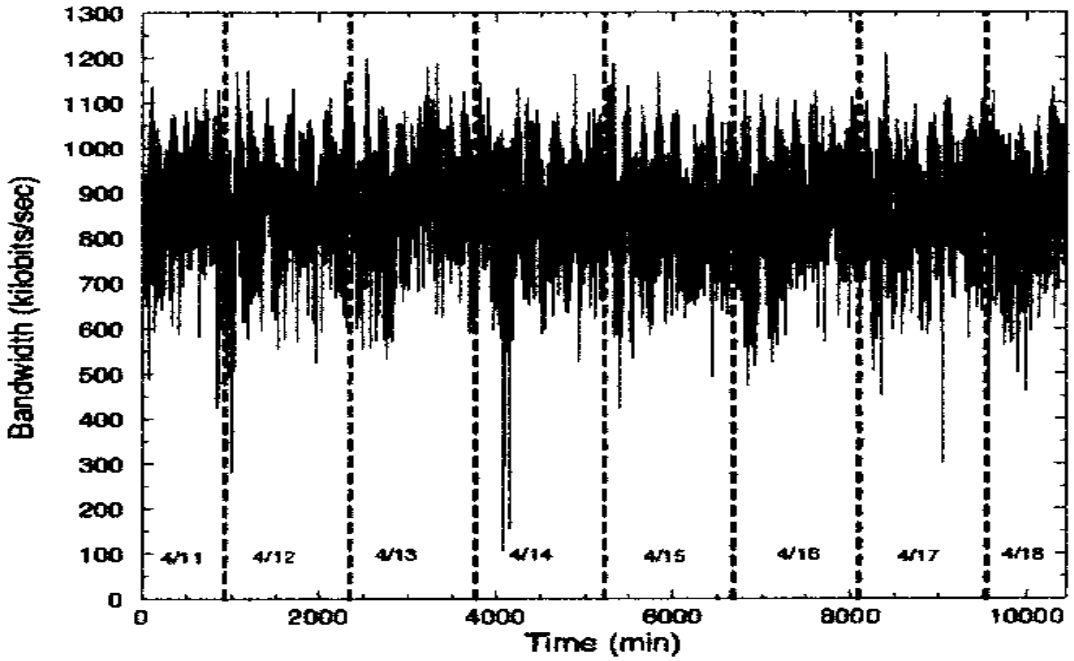


Fig. 1. Per-minute bandwidth during trace

Server Load – Total Packet rate

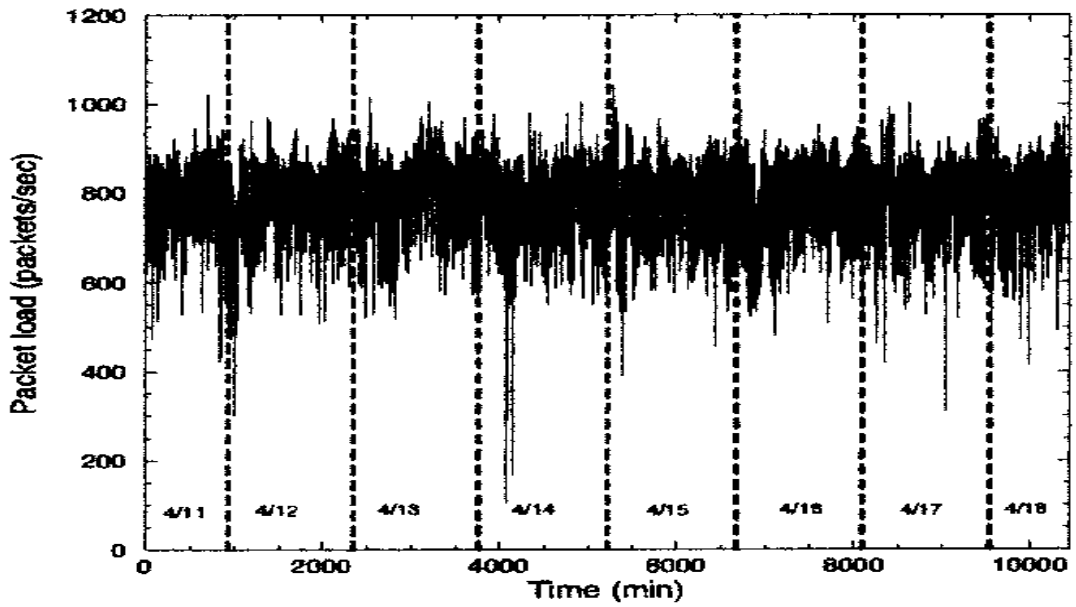


Fig. 2. Per-minute packet load during trace

No. of Players

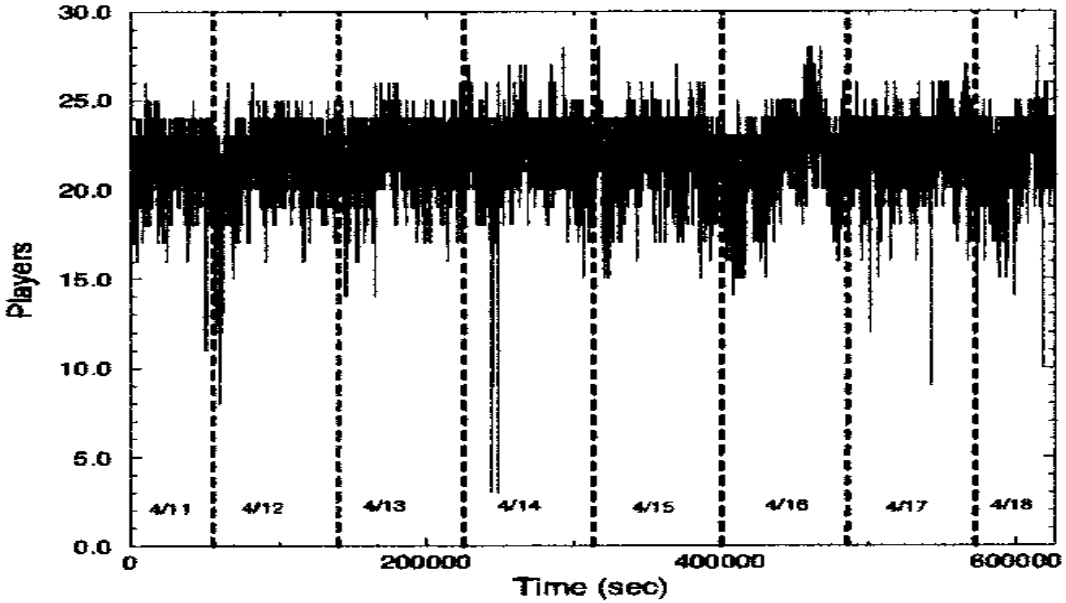
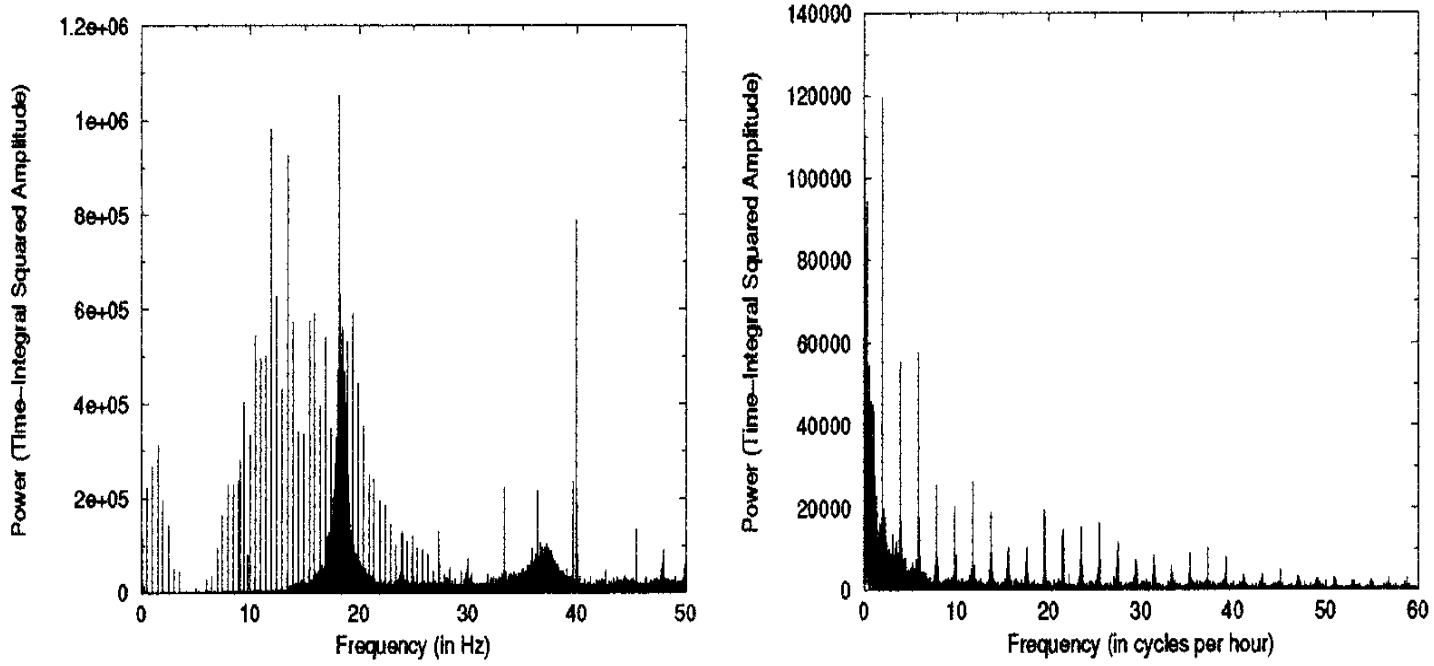


Fig. 3. Per-minute number of players for entire trace

Power Spectral Density



(a) 10ms samples (4/11)

(b) 1s samples (entire trace)

Fig. 4. Power spectrum density plots of the packet rate of trace

Packet load over 10ms intervals

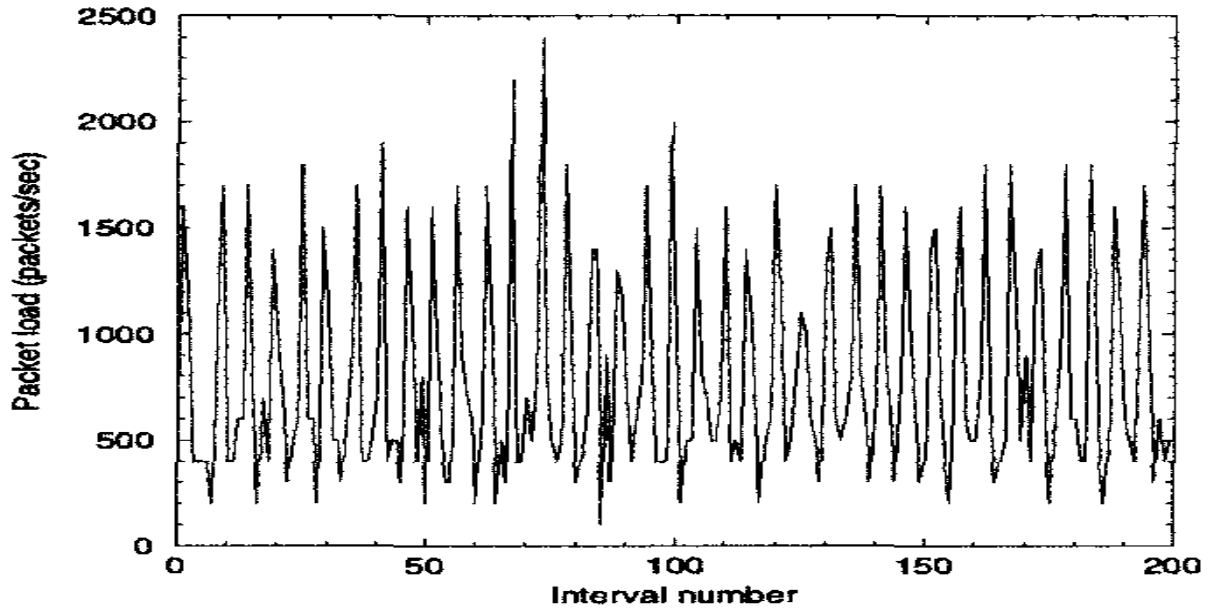
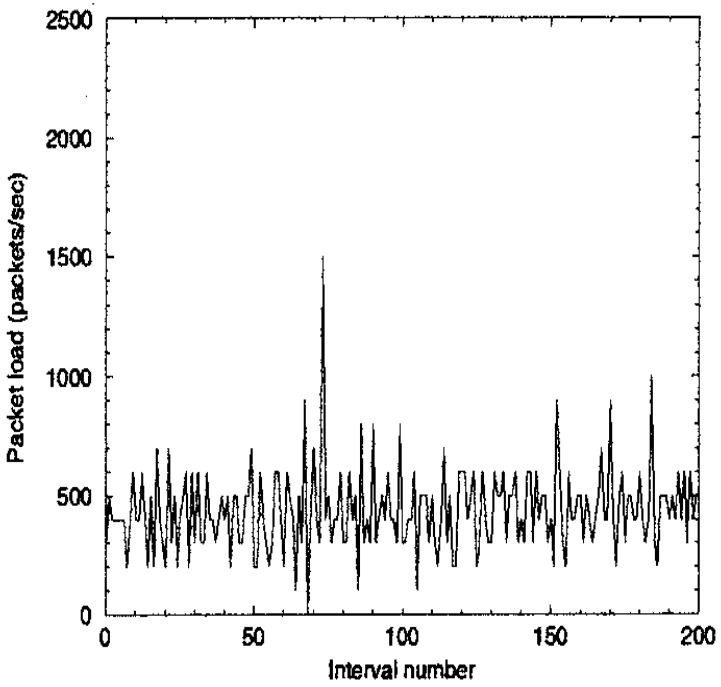
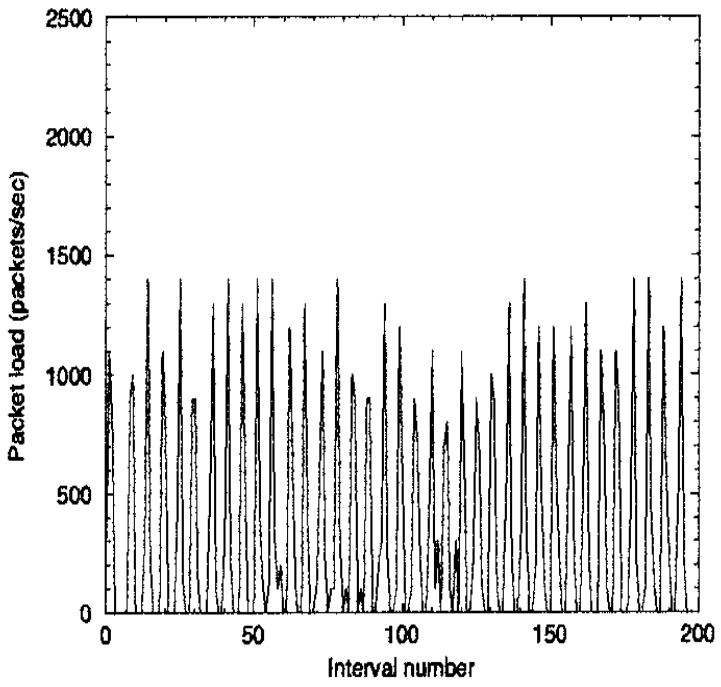


Fig. 5. Total packet load for the $m = 10ms$ interval size

In and Out packet load



(a) Incoming packet load



(b) Outgoing packet load

Fig. 6. Incoming and outgoing packet load for the $m = 10ms$ interval size

Total packet load over different timescales – 50ms – smoothed over update interval

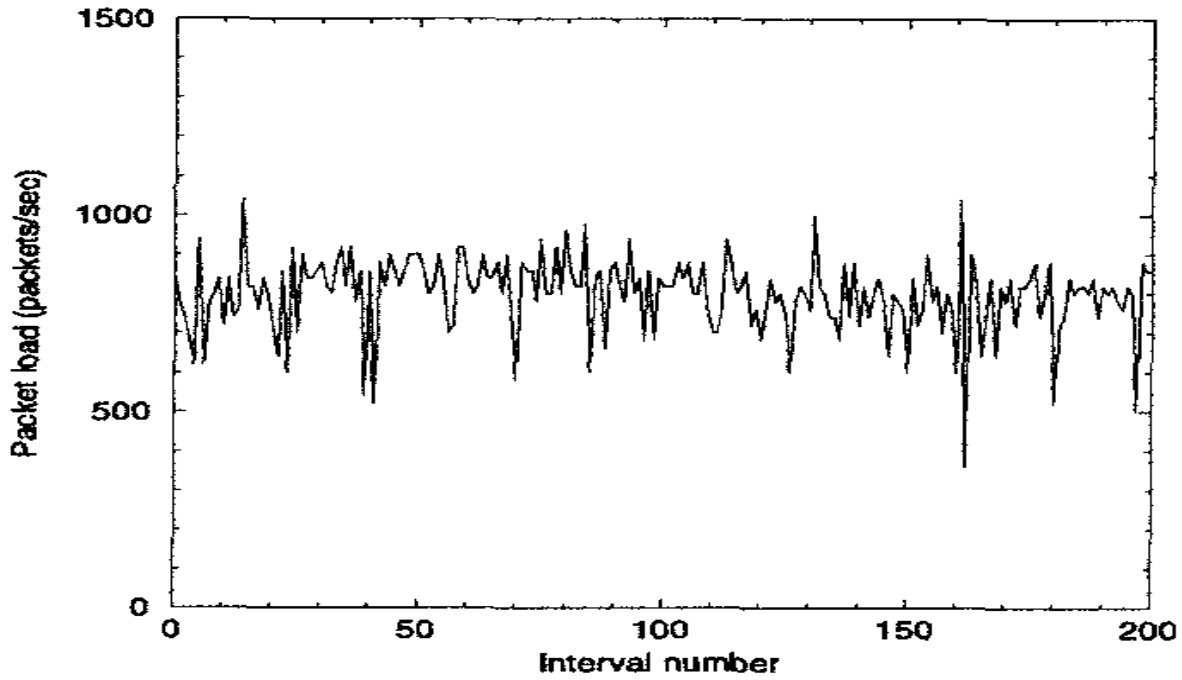


Fig. 7. Total packet load plot for $m = 50ms$

Timescale is 1sec – lull every 30mins when map changed

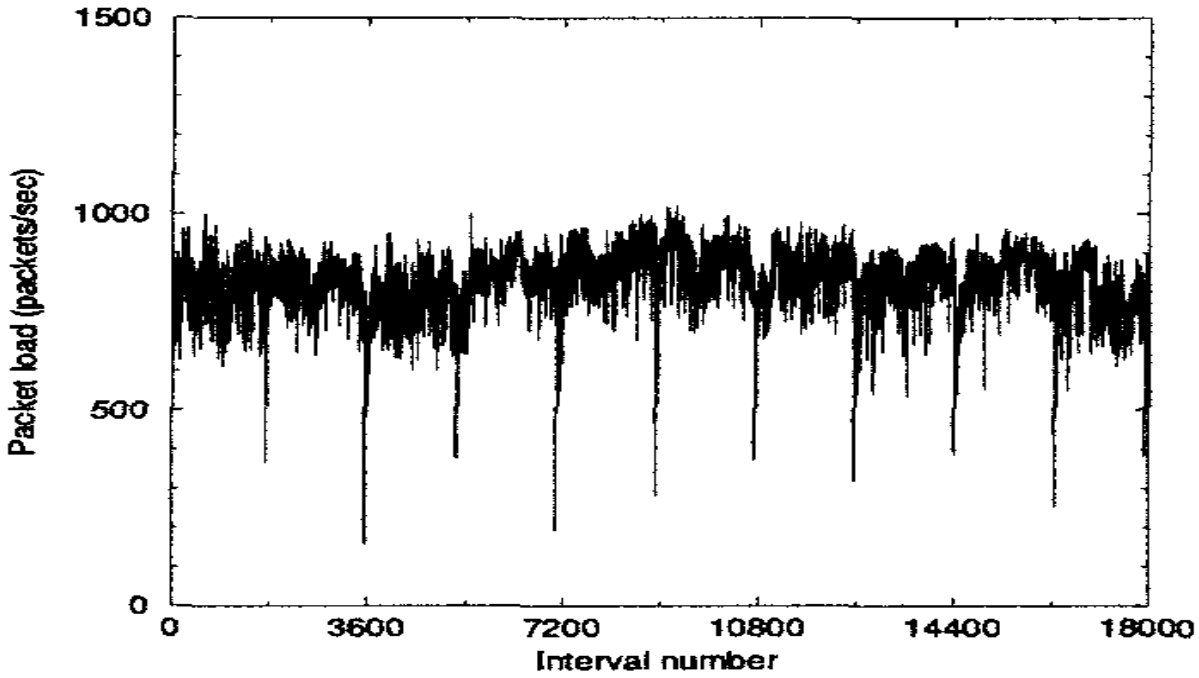


Fig. 8. Total packet load plot for $m = 1sec$

Smoothed over 30mins – map change interval

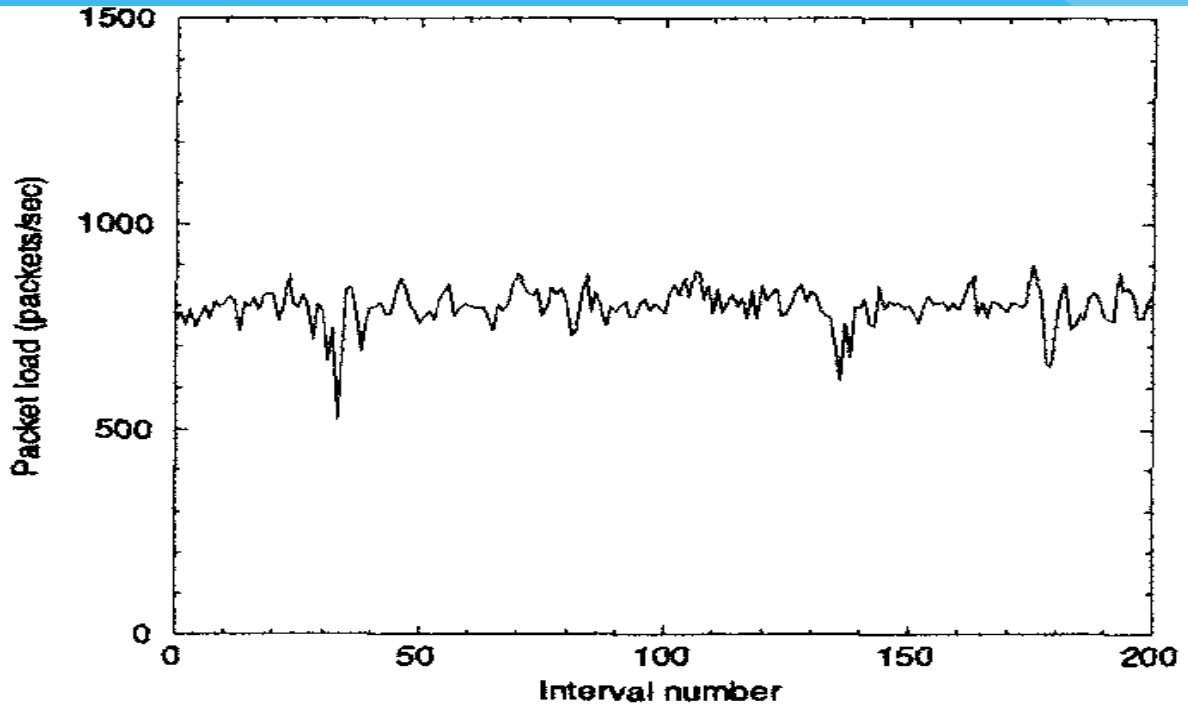


Fig. 9. *Total packet load plot for* $m = 30min$

Client bandwidth

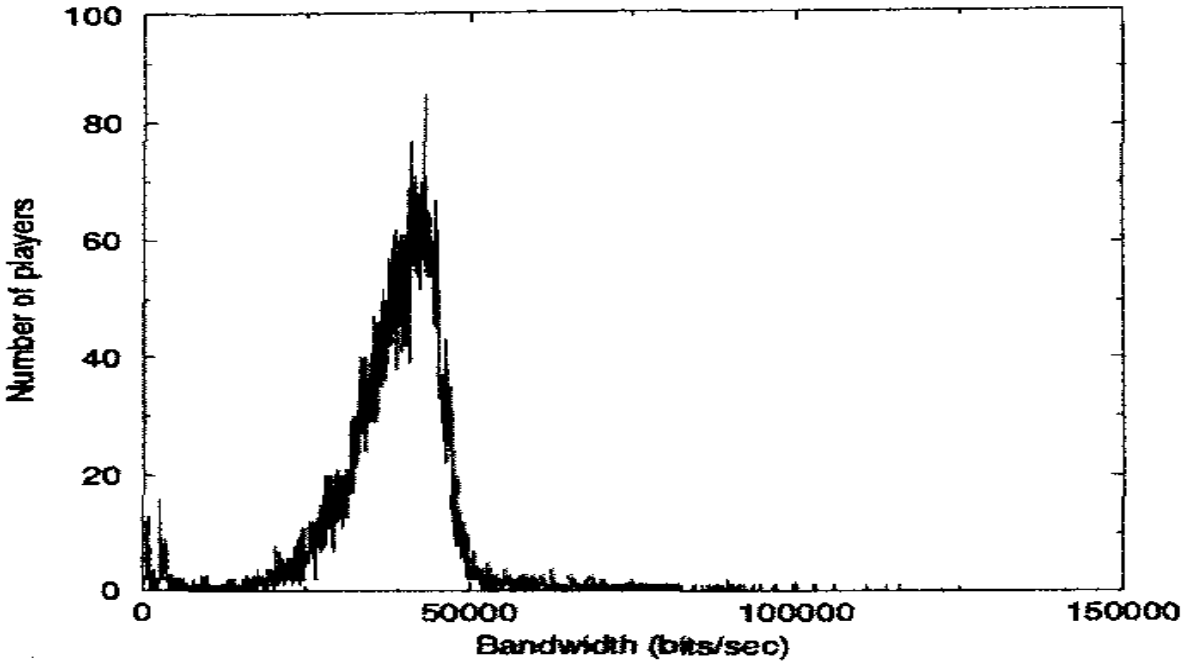


Fig. 10. Client bandwidth histogram

Packet size data

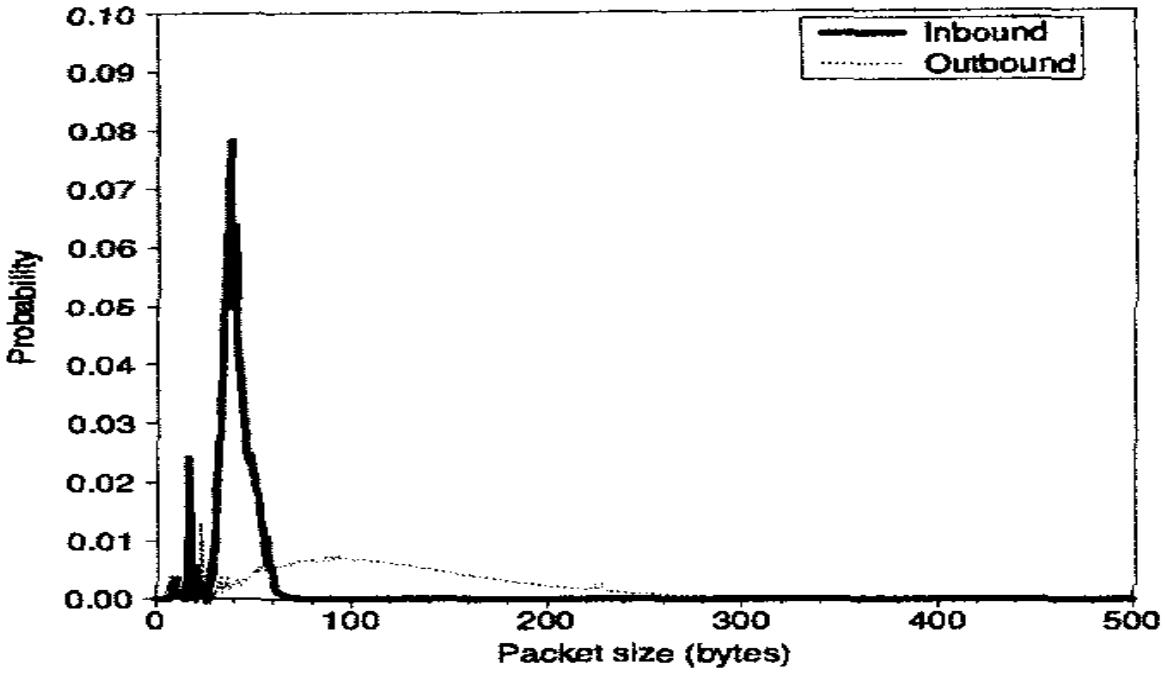


Fig. 11. Packet size PDF

Client Session Duration - CDF

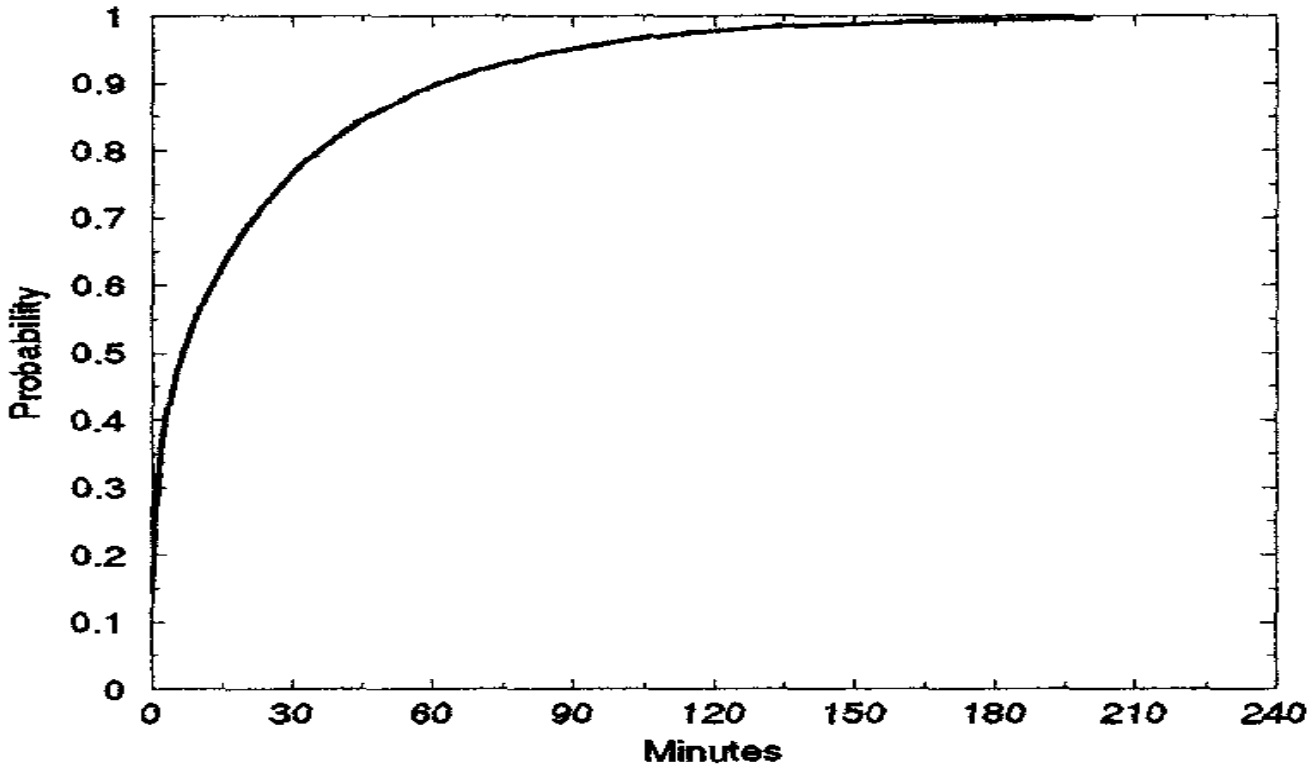


Fig. 12. Session time CDF for mshmro trace

PDF of Player Quitting Time (Failure rate)

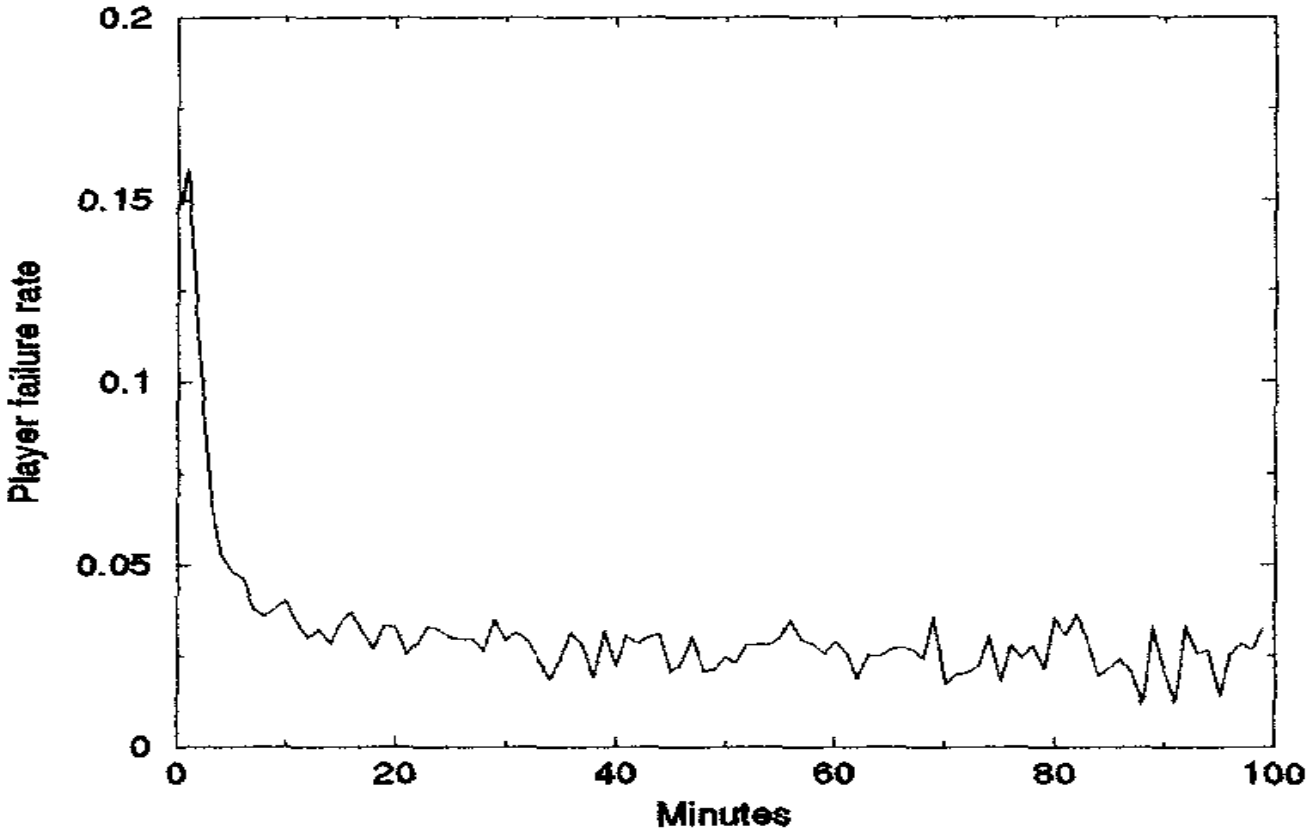


Fig. 14. Player failure rates for individual session times

Weibull Distribution

Definition

A random variable X is said to have a **Weibull distribution** with parameters α and β $(\alpha > 0, \beta > 0)$ if the pdf of X is

$$f(x;\alpha,\beta) = \begin{cases} \frac{\alpha}{\beta^\alpha} x^{\alpha-1} e^{-(x/\beta)^\alpha} & x \geq 0 \\ 0 & x < 0 \end{cases}$$

Remark:

1. The family of Weibull distributions was introduced by the Swedish physicist Waloddi Weibull in 1939.
2. We use $X \sim \text{WEB}(\alpha, \beta)$ to denote that the rv X has a Weibull distribution with parameters α and β.

Weibull Distr. Contd.

Remark:

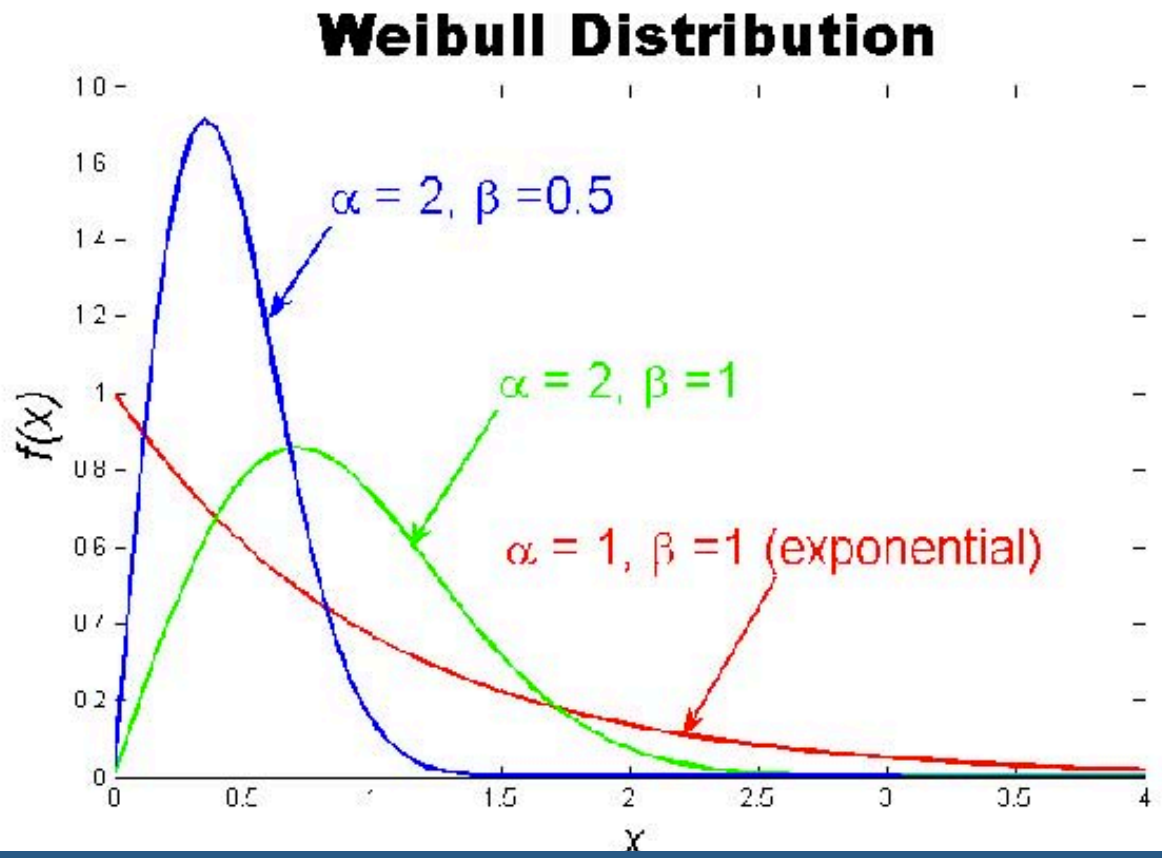
3. When $\alpha = 1$, the pdf becomes

$$f(x;\beta) = \begin{cases} \frac{1}{\beta} e^{-x/\beta} & x \geq 0 \\ 0 & x < 0 \end{cases}$$

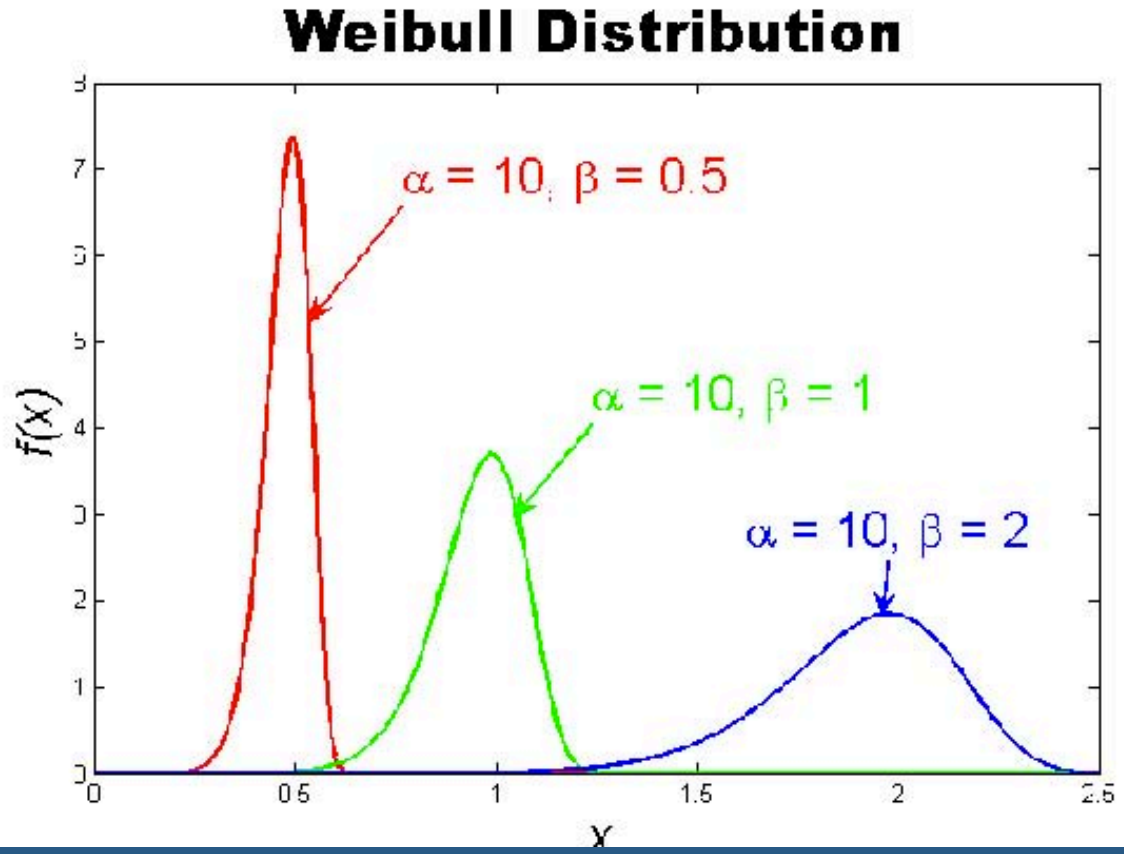
which is the pdf for an exponential distribution with parameter $\lambda = \frac{1}{\beta}$. Thus we see that the exponential distribution is a special case of both the gamma and Weibull distributions.

4. There are gamma distributions that are not Weibull distributios and vice versa, so one family is not a subset of the other.

Weibull Distr. Contd.



Weibull Distr. Contd.



Weibull Distr. contd.

Proposition

Let X be a random variable such that $X \sim WEI(\alpha, \beta)$. Then

$$E(X) = \beta\Gamma\left(1+\frac{1}{\alpha}\right) \quad \textit{and} \quad V(X) = \beta^2\left\{\Gamma\left(1+\frac{2}{\alpha}\right) - \left[\Gamma\left(1+\frac{1}{\alpha}\right)\right]^2\right\}$$

The cdf of X is

$$F(x;\alpha,\beta) = \begin{cases} 1 - e^{-(x/\beta)^\alpha} & x \geq 0 \\ 0 & x < 0 \end{cases}$$

PDF for Client Session Duration – Weibull Distr.

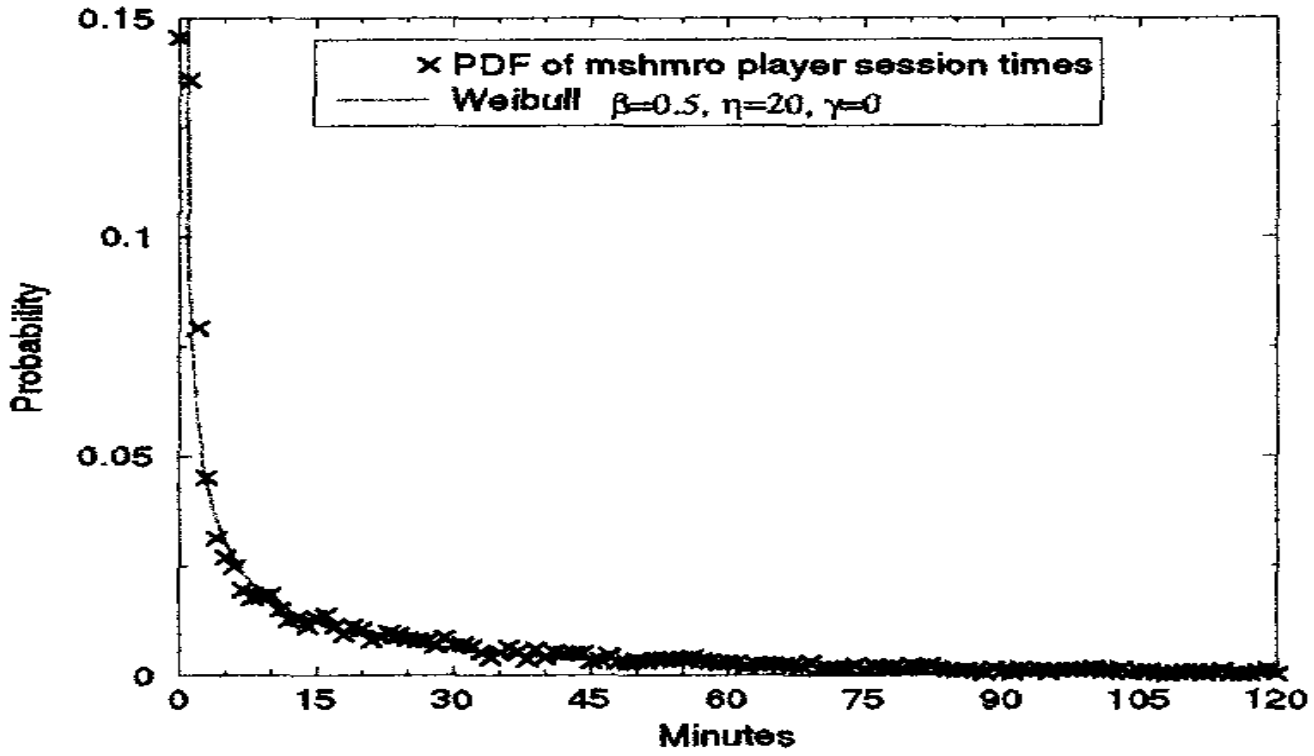


Fig. 13. Fitted Weibull distribution on session time PDF of mshmro trace

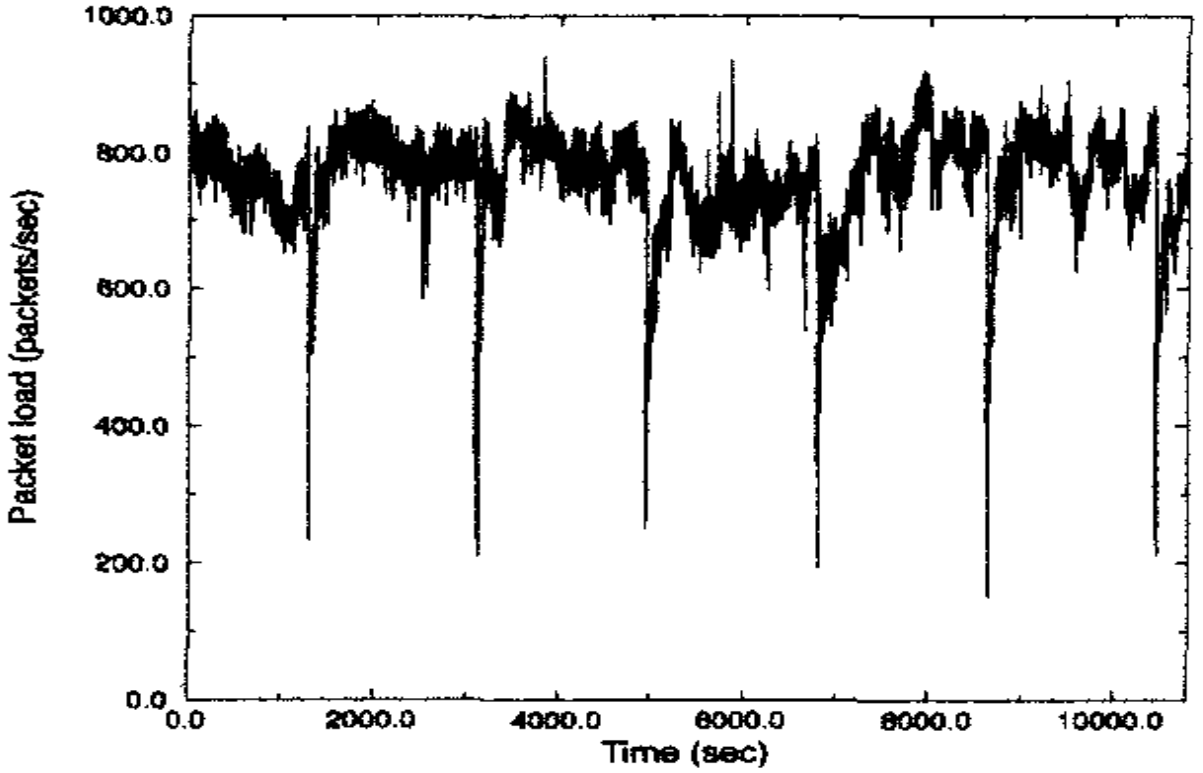
Cross Check with other games statistics

Day of Defeat	
Start Time	Sun Jul 28 23:00:00 2002
Stop Time	Mon Jul 29 02:00:00 2002
Packet rate (in/out)	421.85*pps*/341.92*pps*
Packet size (in/out)	41.73*bytes*/162.78*bytes*
Medal of Honor: Allied Assault	
Start Time	Thu Jul 25 01:00:00 2002
Stop Time	Thu Jul 25 04:00:00 2002
Packet rate (in/out)	379.67*pps*/294.10*pps*
Packet size (in/out)	50.10*bytes*/291.71*bytes*
Unreal Tournament 2003	
Start Time	Thu Oct 17 00:00:00 2002
Stop Time	Thu Oct 17 03:00:00 2002
Packet rate (in/out)	469.89*pps*/123.43*pps*
Packet size (in/out)	27.92*bytes*/117.74*bytes*

TABLE III

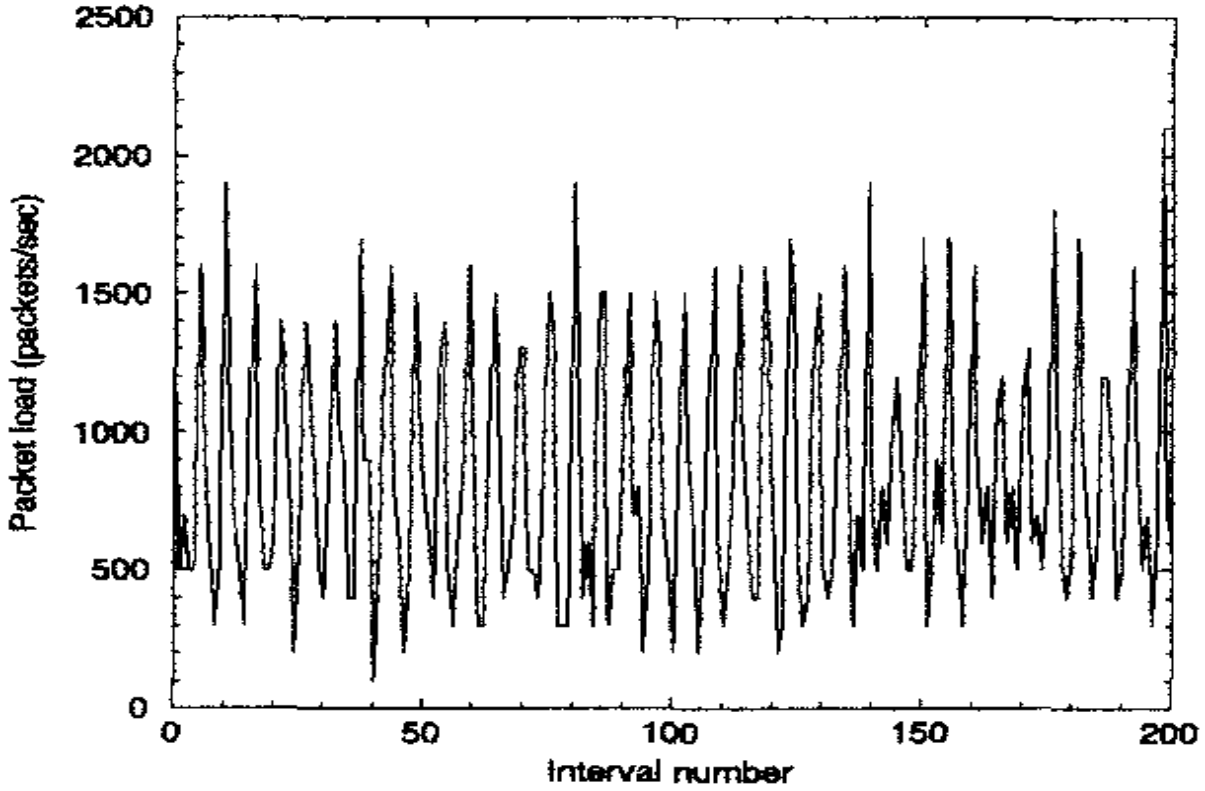
TRACE SUMMARIES FOR OTHER FPS GAMES

Day of Defeat – similar map change time, and server updates



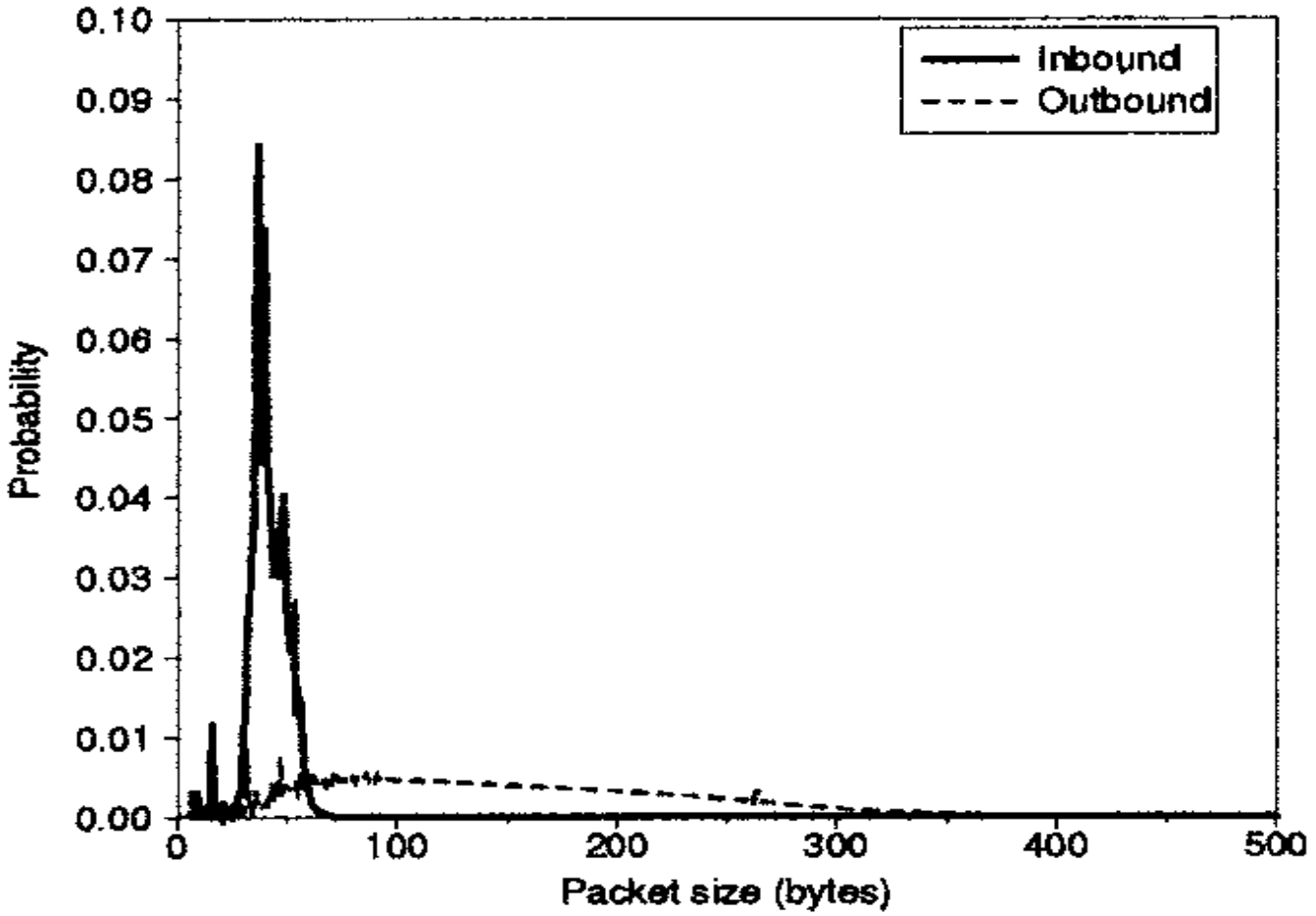
(a) Per-second packet load over trace

Day of Defeat contd.



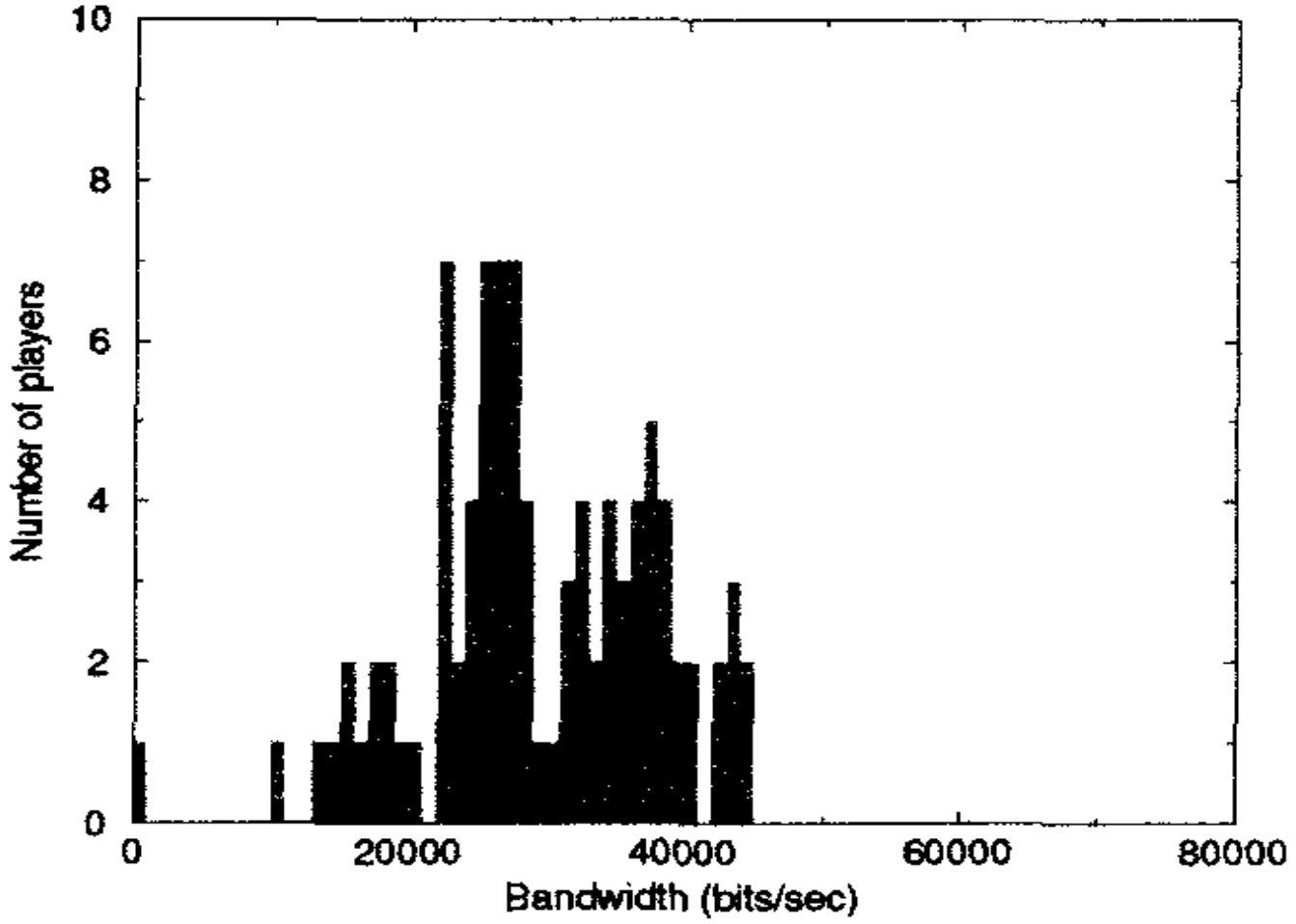
(b) Total packet load plot for $m = 10ms$

Day of Defeat contd.



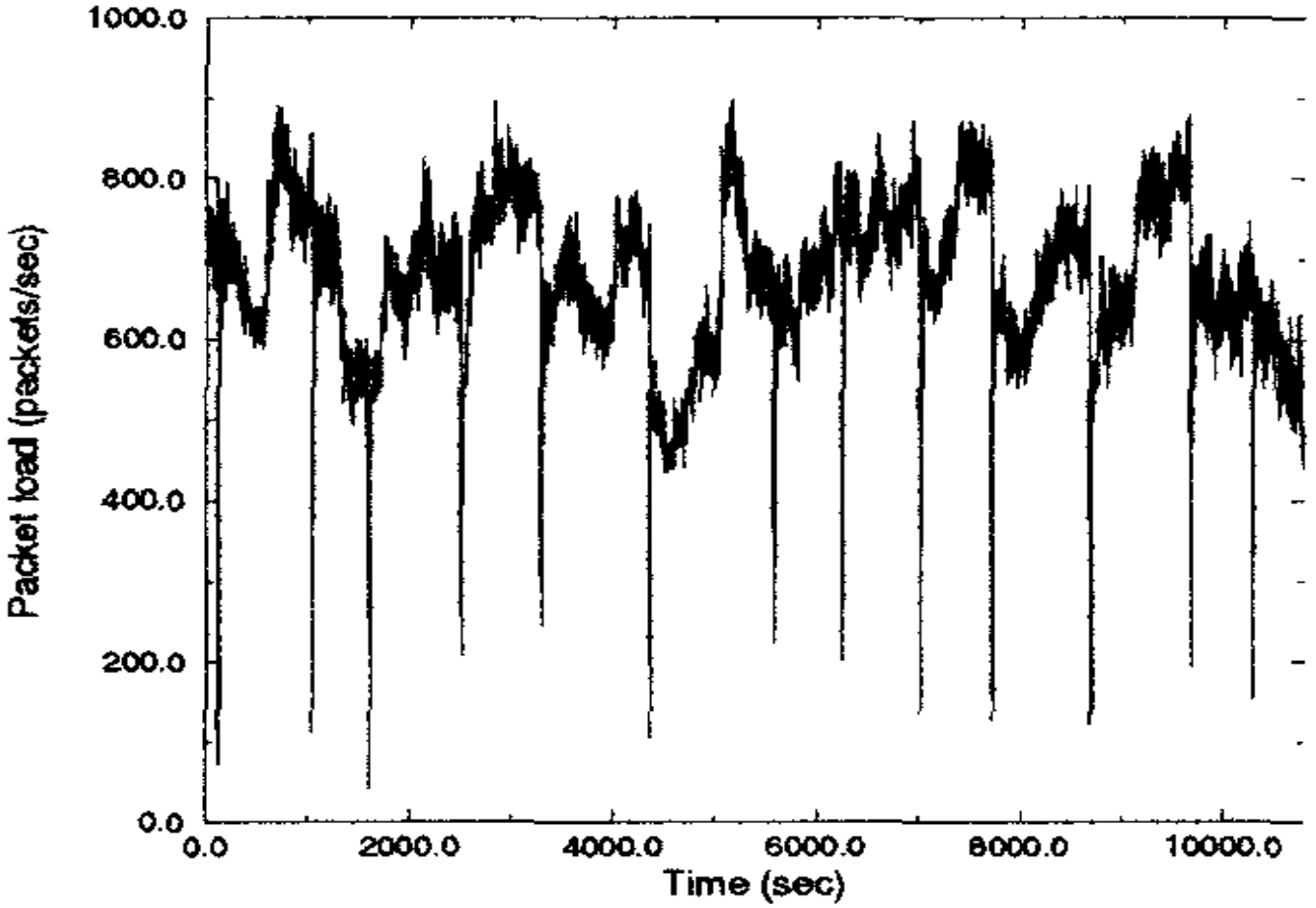
(c) Packet size PDF

Day of Defeat contd.



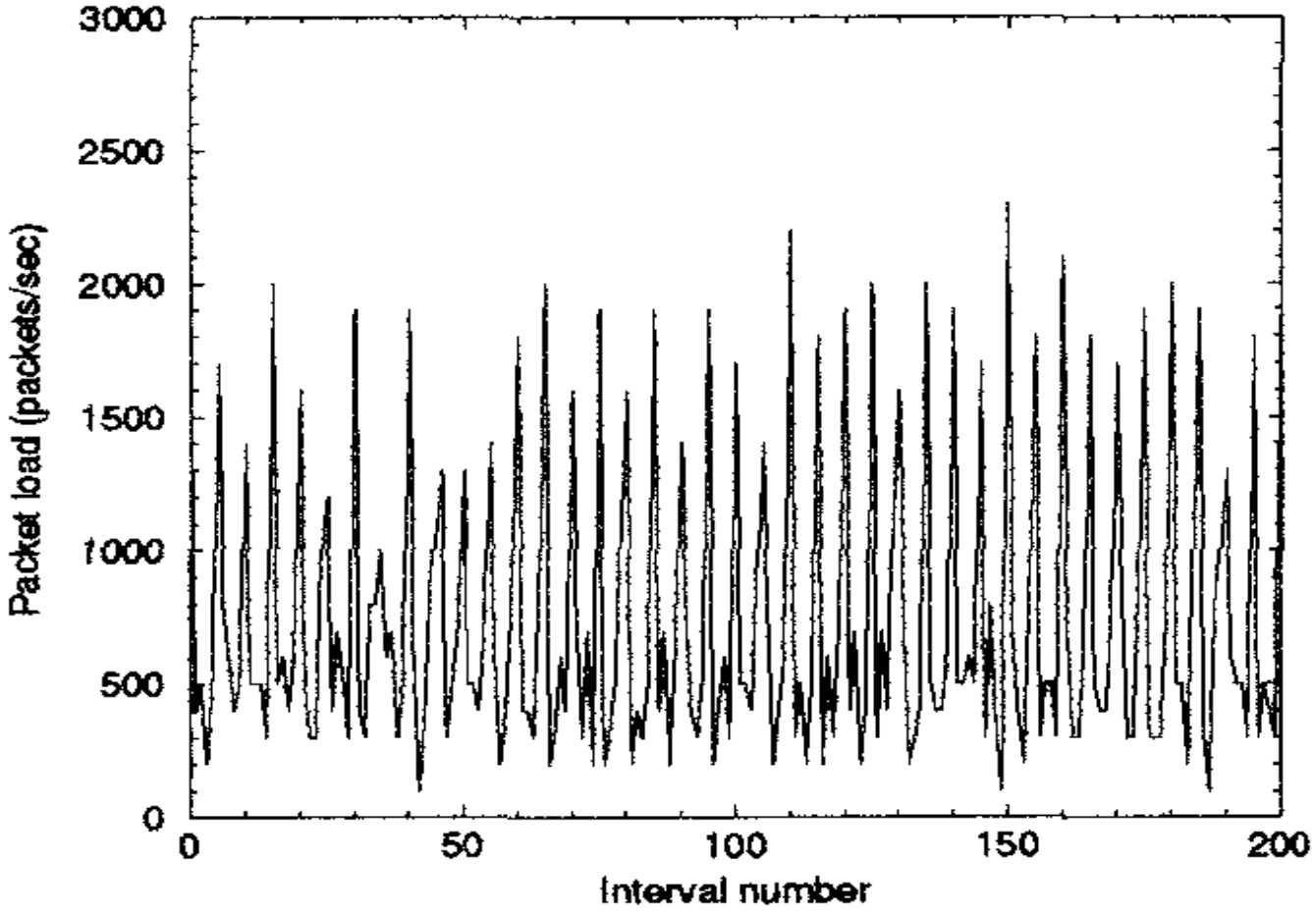
(d) Client bandwidth histogram

Medal of Honor



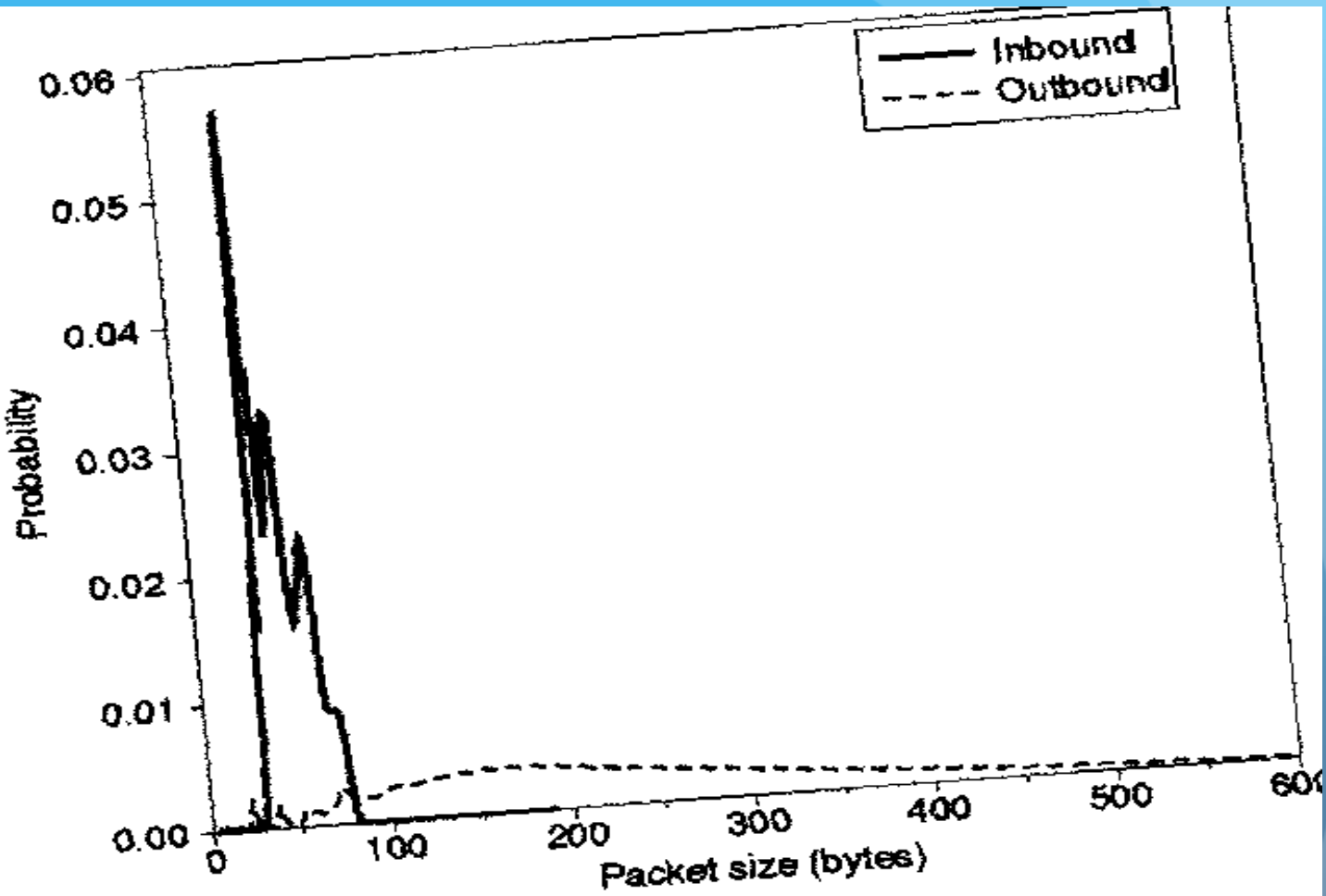
(a) Per-second packet load over trace

Medal of Honor contd.



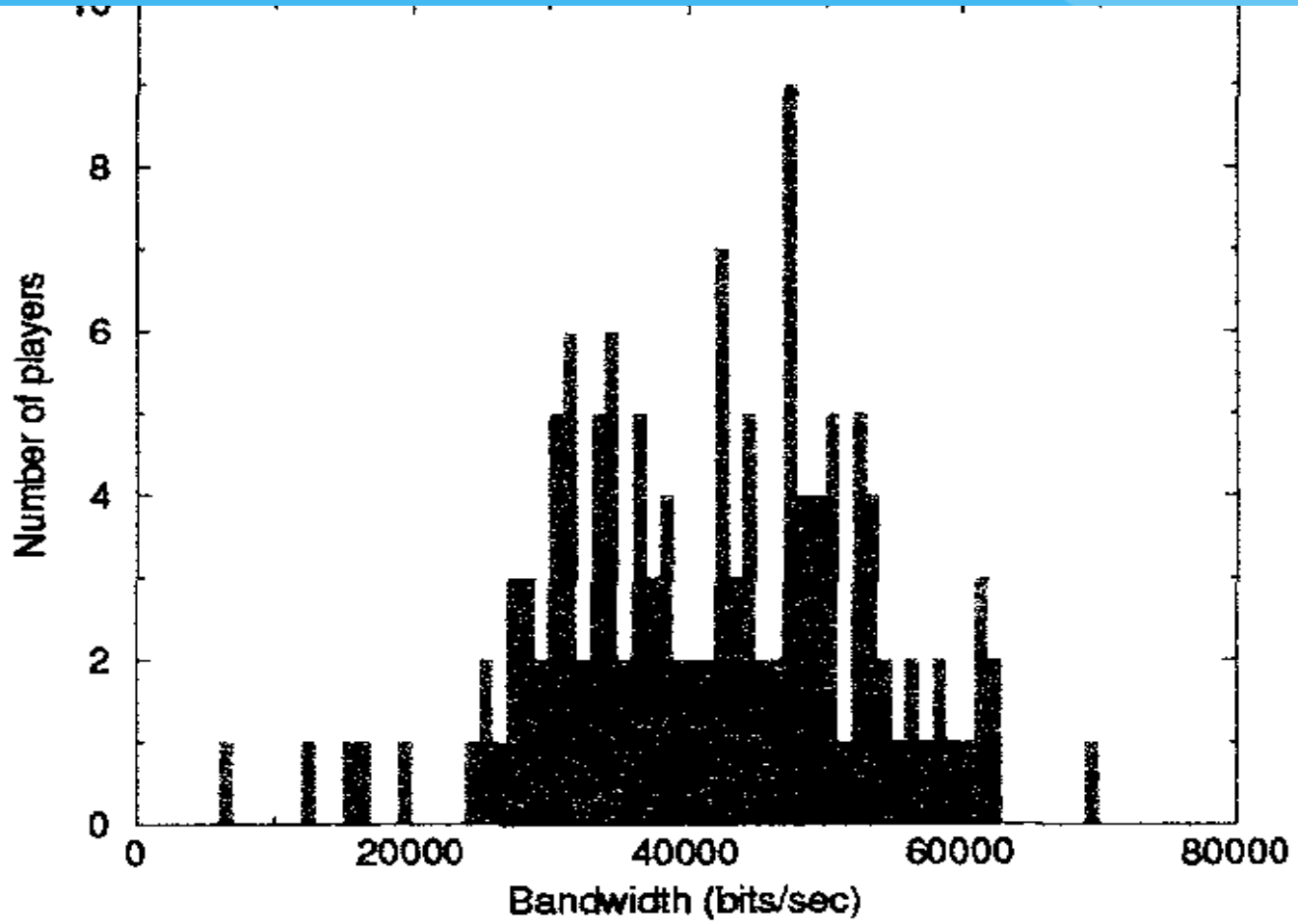
(b) Total packet load plot for $m = 10ms$

Medal of Honor contd.



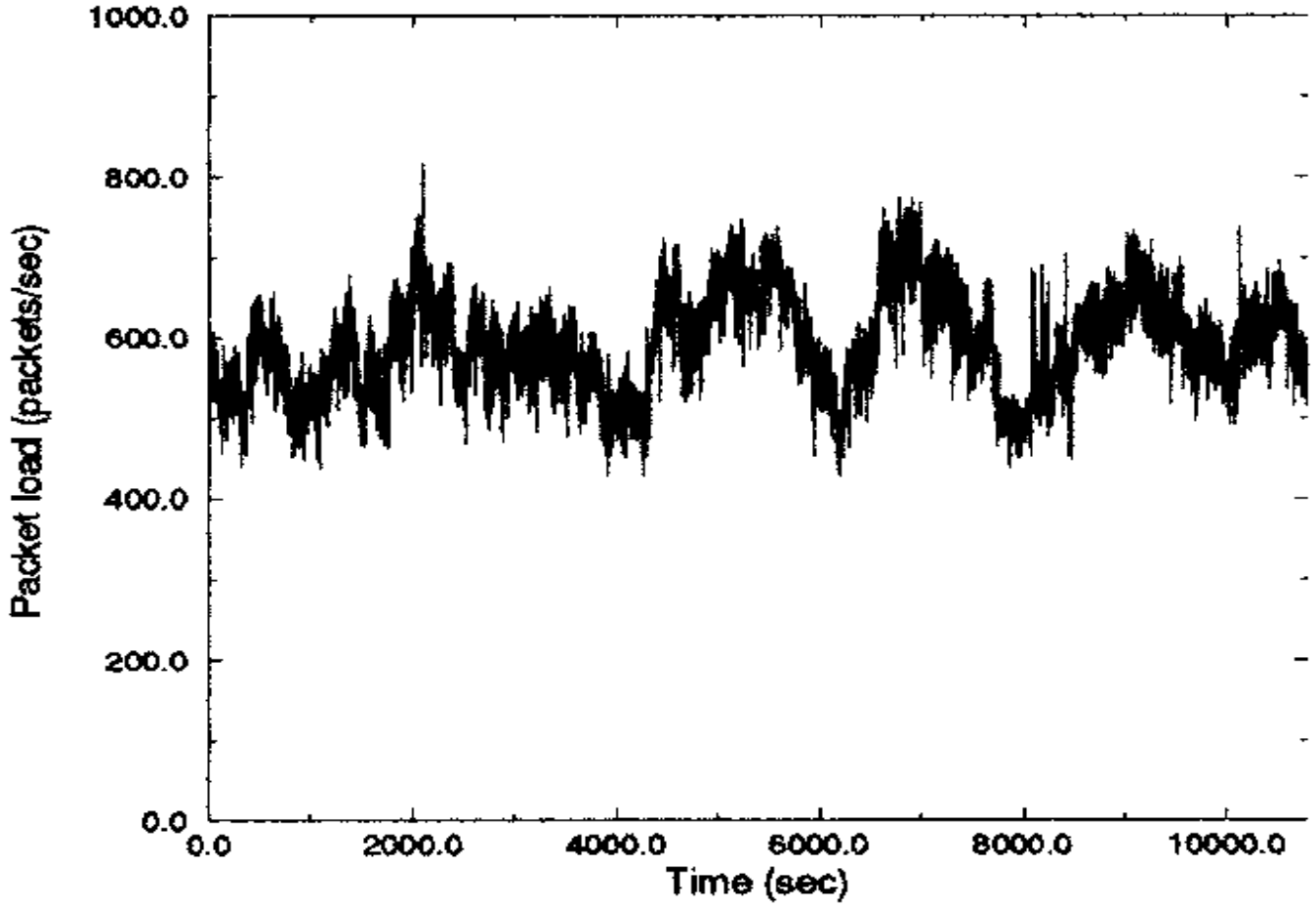
(c) Packet size PDF

Medal of Honor contd.



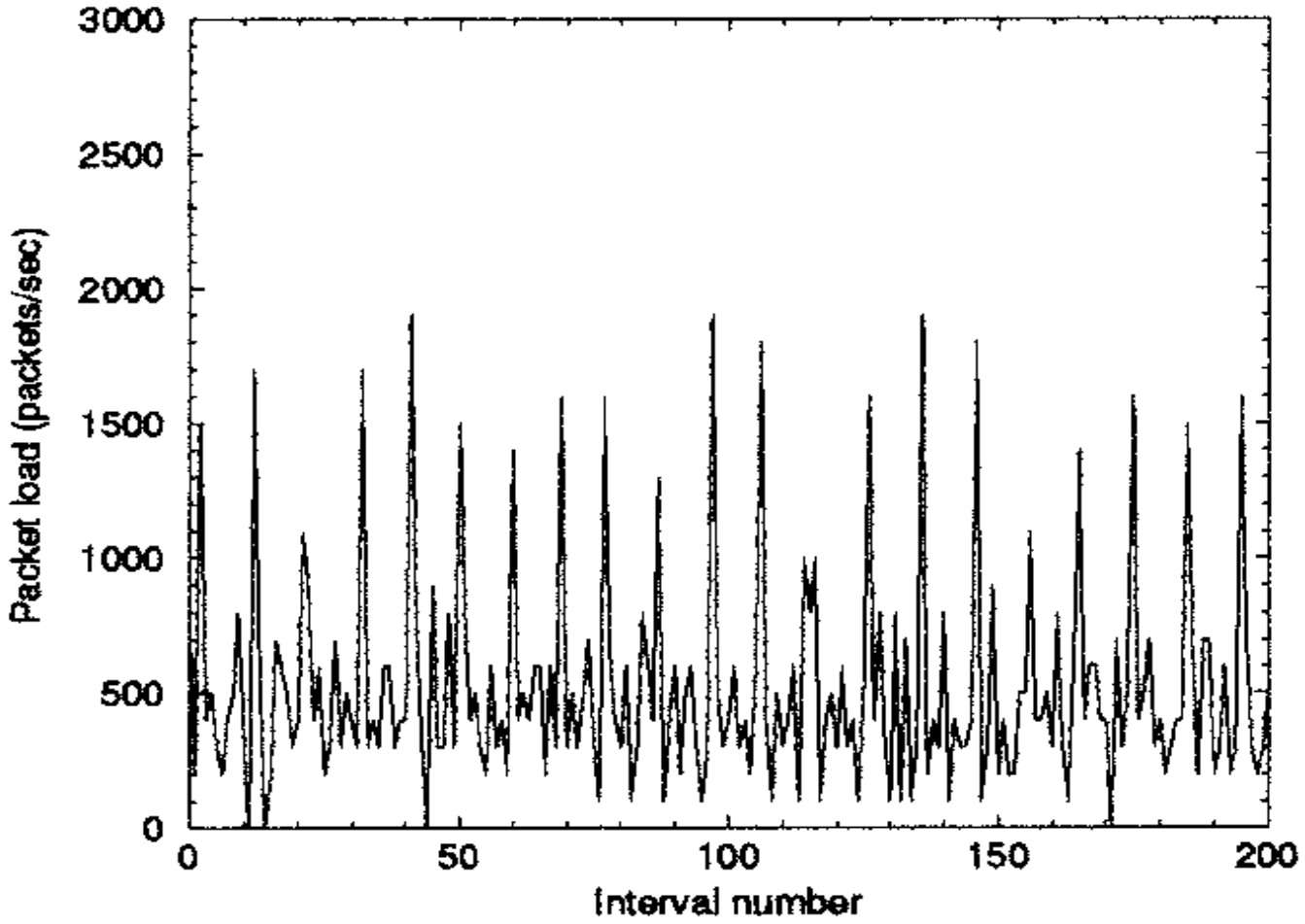
(d) Client bandwidth histogram

Unreal Tournament 2003



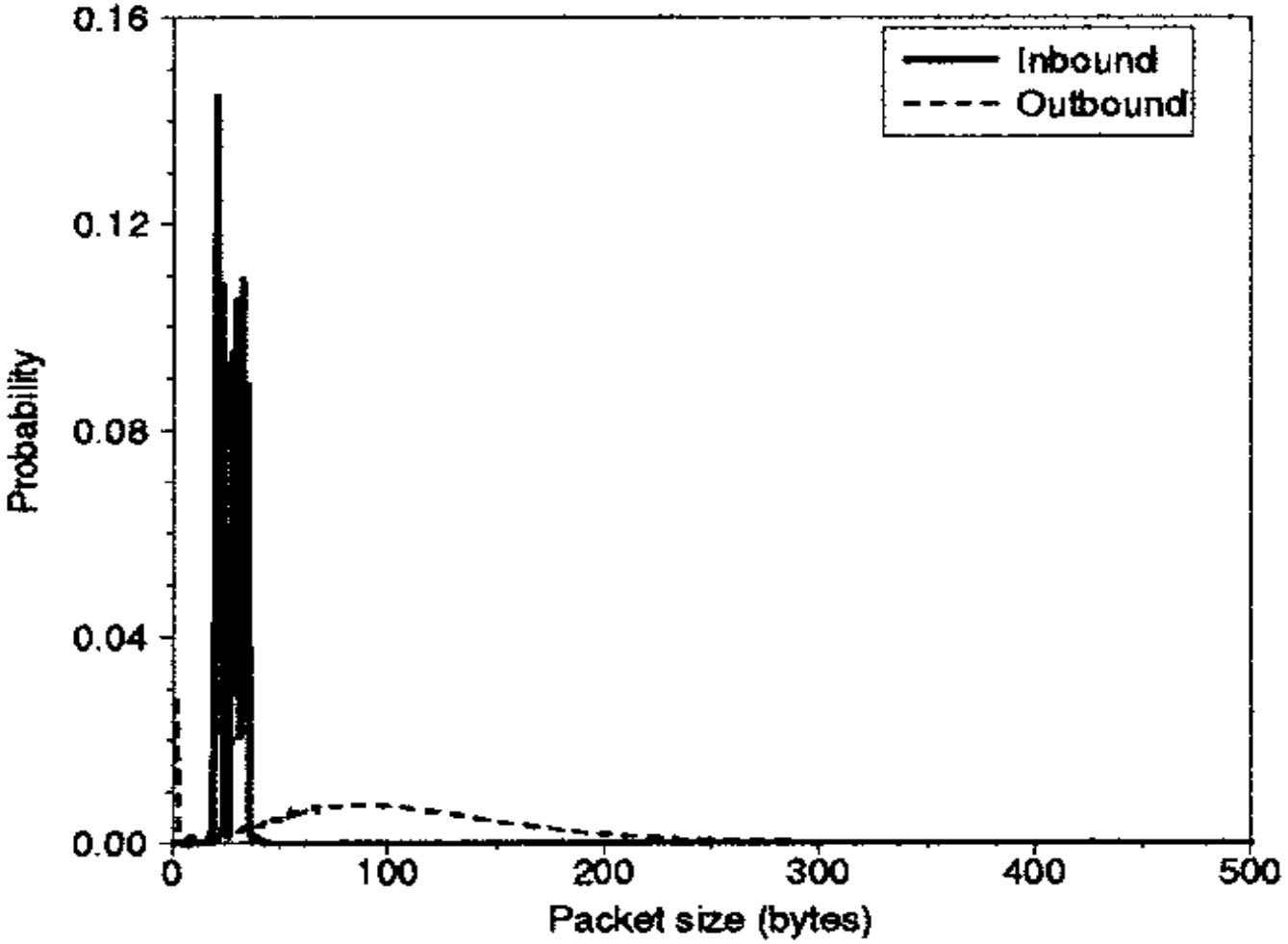
(a) Per-second packet load over trace

Unreal Tournament contd.



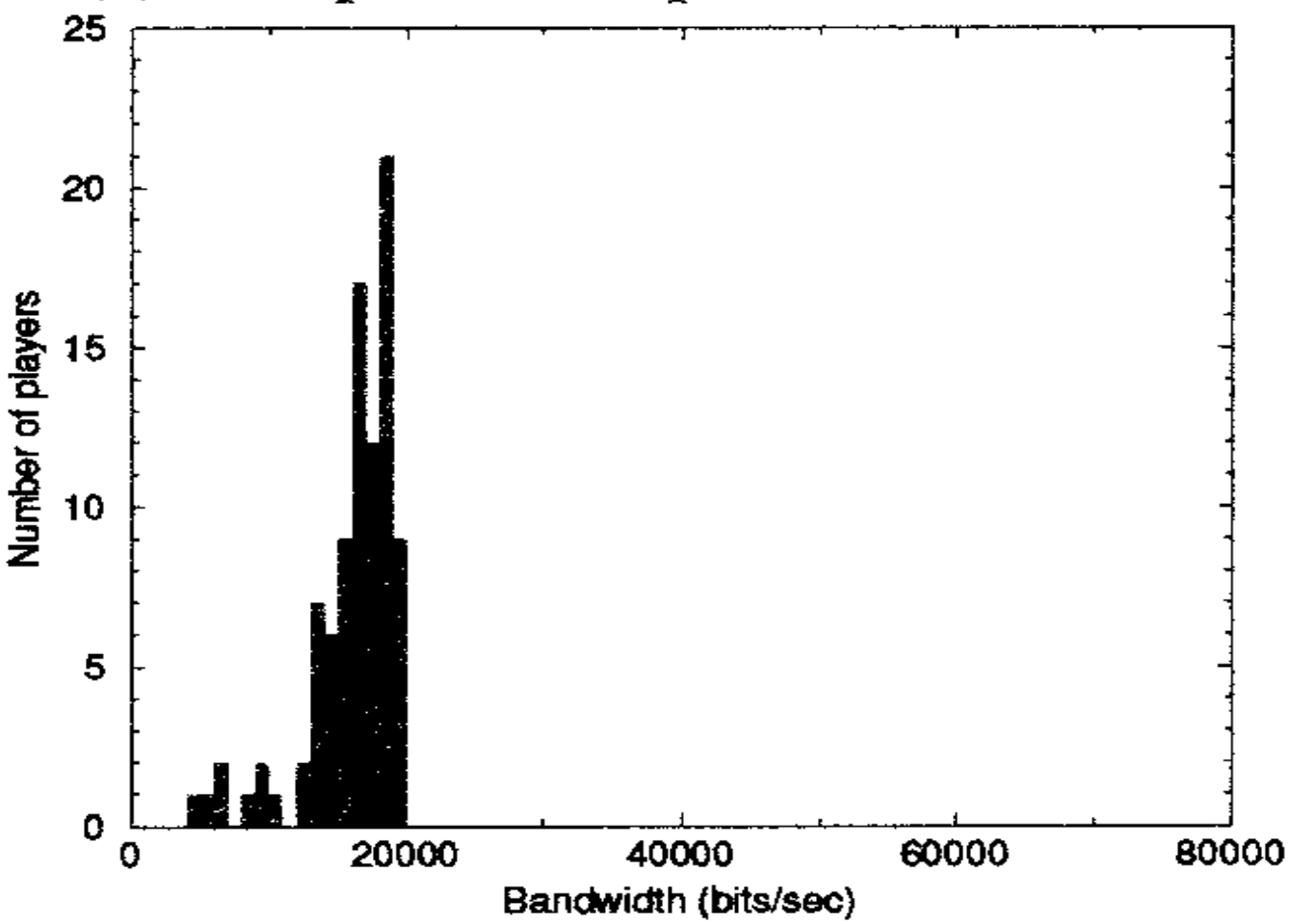
(b) Total packet load plot for $m = 10ms$

Unreal Tournament contd.



(c) Packet size PDF

Unreal Tournament contd.



(d) Client bandwidth histogram

Conclusions

- Periodic large bursts of short packets
  - Regular server updates
  - Short client action data for interactivity
- Most internet traffic is TPC carrying large data packets
- Routers designed for handling large packets – game traffic entails many more routing table lookups
- Packet losses and delays greatly impact game performance
- Larger buffers not solution – active queue management must be done