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Characteristics of WAP Traffic

Irene C. Y. Ma and James Irvine

University of Strathclyde - Department of Electronic and Electrical Engineering – 204 George St. – Glasgow G1 1XW – Scotland

Ph.: + 44 141 548 4072, Fax: + 44 141 552 4968, e-mail: j.m.irvine@strath.ac.uk

ABSTRACT

This paper considers the characteristics of WAP traffic. We start by constructing a model of WAP traffic based on a number of user scenarios. One traffic characteristic which is of particular interest in network dimensioning is the degree of self-similarity, so the paper looks at the characteristics of aggregated traffic with WAP, web and packet speech components to estimate its self-similarity. The results indicated that, while WAP traffic alone does not exhibit a significant degree of self-similarity, a combined load from various traffic sources retains almost the same degree of self-similarity as the most self-similar individual source.

1. INTRODUCTION

Wireless Application Protocol (WAP) [1] is a protocol for the transmission of web like content to mobile phones and other (usually wireless) devices with low-bandwidth links. Although commercial take-up has been slower than originally hoped, WAP is still offers considerable promise as more content tailored to small devices becomes available.

The standard WAP configuration is to have a WAP terminal communicating with a WAP gateway, which is then connected to the web. The terminal sends its request to the gateway, which then requests the content from the web server. The web server replies to the request with WML (Wireless Markup Language) files which the gateway can then optimise for transmission over the low bandwidth link to the terminal. A modified approach which allows the browsing of standard web pages is to use an HTML filter to convert the HTML pages to WML, but on devices with small displays this is unlikely to be successful, with content having to be tailored to the device. Proposals for WAP 2.0 allow selection of information depending on the capabilities of the device, but this paper deals with the current WAP specification (1.2).

There is little in the literature on the modelling of WAP traffic. One approach to modelling WAP traffic would be to modify an existing web traffic model, taking into account the optimising (effectively compression) which is carried out by the gateway and HTML filter. However, with the exception of some PDAs which now have WAP browsers, most WAP devices have a very limited user interface which affects the way people use the device. Most WAP browsing uses WML pages directly rather than the HTML filter, and a simple conversion from a web model is not therefore appropriate. In addition, the relatively high costs of using WAP on a mobile phone in many cases reduces casual browsing. Information retrieved through high cost WAP services needs to be of value, and for it to be accessed on the move, time sensitive, at least from the point of view of the user.

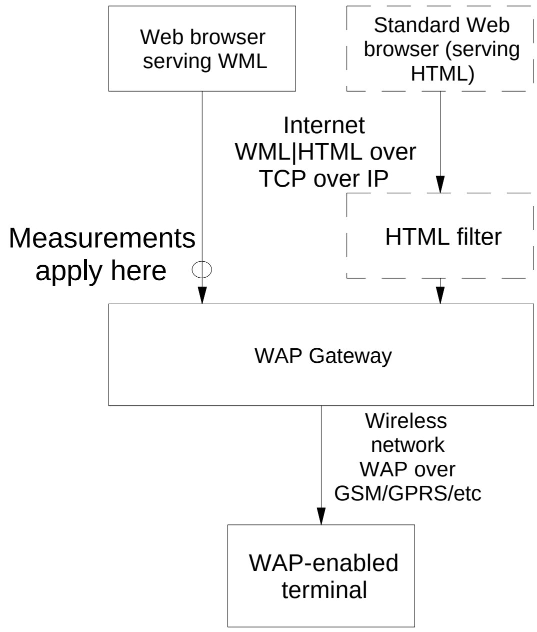

Figure 1 WAP System

Another difficulty with a web model is that a web page usually consists of a main page with a number of other files, such as images, included within it. Web models therefore differentiate between the reading time for a complete page between page requests, and the loading times of files within a page [2]. WAP traffic has fewer images and smaller pages which are read more quickly, reducing this distinction.

As well as constructing a model for WAP traffic, it is interesting to consider the effect of WAP traffic on the overall aggregate traffic through the system. One major difficulty in the dimensioning of capacity for Internet traffic is due to the self-similarity of Web browsing traffic pattern. Self-similar traffic possesses the property that, when aggregated over time, the distribution of the trace remains. Web traffic displays structural self-similarities, and is therefore is bursty, over different time scales. This means that neither the aggregation of the series over longer periods nor the superimposition of multiple sources would result in a smoother traffic pattern. In other words, the total traffic in the core network is just as bursty as the traffic being generated by one single Web user. This would imply that the amount of buffering or allowance that needs to be provisioned in the network to enable sufficient resources at all time has to be infinite, which is obviously impossible from a practical point of view. Therefore, it becomes difficult to both efficiently and adequately provision capacity to handle internet traffic, when up to 70% comes from Web browsing traffic [8], a highly self-similar type of traffic.

2. SCENARIOS

In order to investigate the traffic generated in a WAP session, a number of scenarios were developed to represent typical data transactions. When this was done, two distinct scenario types developed distinguished by the reading time or lack of it: look-up or browse. In a look-up scenario, the user is attempted to find a specific fact. This normally involves the navigation of a number of pages, but the reading time of these intermediate pages is very small, especially if the user is familiar with the site. However, the nature of the user interface on a phone means that there is a significant navigation time. Examples include finding the weather in a specific location, or a stock price. Several facts can be found on a look-up session but there will only be one meaningful reading time per transaction. In a browse session, the information is given to the user as the site defines it rather than the user explicitly requesting each fact. An example would be reading the news, or browsing a shopping site (although a focussed visit to a shopping site which the user was buying a specific product from would probably be a 'lookup'). In the browse case, WAP traffic does exhibit reading times, although these are smaller than for web scenarios. The distinction is not clear cut – visiting a travel site costing a number of different travel options could either be considered to be a 'browse' or an number of different 'look-up's.

University students were used to conduct the scenarios. Runs from different students of the same scenarios were averaged for analysis to construct the model, but example scenarios were individually analysed in order to check the various found between them (which except for the variation between look-up and browse was small).

3. TESTBED

To measure WAP traffic, a testbed was constructed consisting of a WAP emulator on a PC (YOURWAP Release 2.11 from YOURWAP.com) and a proxy server modified to monitor the WML traffic payload. The proxy was connected to the campus network at the University of Strathclyde, which is itself connected to the SuperJanet network. This gives good Internet connectivity, so delays on this system are likely to be low and comparable to those experienced by a gateway on a cellular provider assuming it also has good connectivity. The emulator presented the same user interface as a mobile phone, except that the keys of the 'phone' were pressed by mouse clicks. Using this system, the traffic measured is the WML traffic the gateway has to send to the phone, and is the actual load on the WML server (see Figure 1). The traffic between the gateway and the terminal will be optimised by the gateway for the air interface being used. The gateway may also cache information [1]. Both these aspects are outwith the scope of this paper.

4. WAP MODEL

Look-up scenario: A number of different scenarios were run based on users accessing stock price information and weather forecasts.

No real distinction could be seen between the loading time between objects and reading time for WAP traffic. File interarrival time was modelled reasonably well by an exponential distribution with a mean of about 6 seconds (5.7 sec to 6.3 sec depending on the scenario).

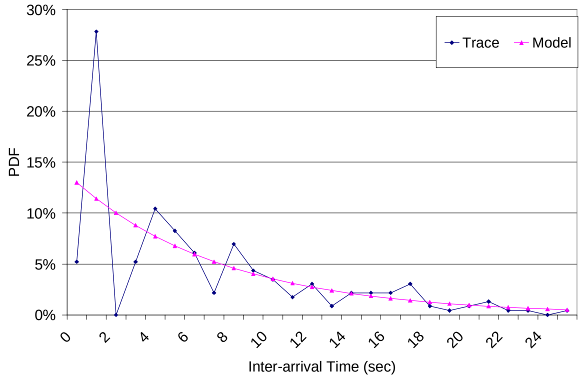

Figure 2 Inter-arrival Time Distribution for WAP-based Stock Price Site (moneyextra)

Regarding file sizes, the nature of the sites meant that there was relatively little variety, with the files or different requests being very similar. Overall, file sizes within a site seemed to uniformly distributed (albeit rather sparsely), with means varying from about 600 bytes to almost 1000.

The mean number of objects returned during a look up session was 10. The number of objects in the session conforms to an exponential distribution.

For comparison, similar scenarios were run for web (i.e. HTML) services. The more advanced user interface allowed the specific information to be found more quickly, and depending on the sites used, average file sizes ranged from between 5K to 10Kbytes, with individual file sizes up to 30K.

Browsing scenario: The browsing scenario chosen was newsreading, with a number of different newsreading sessions undertaken and analysed.

In this case a reading time distribution can be seen clearly (Figure 3). This raises the mean interarrival

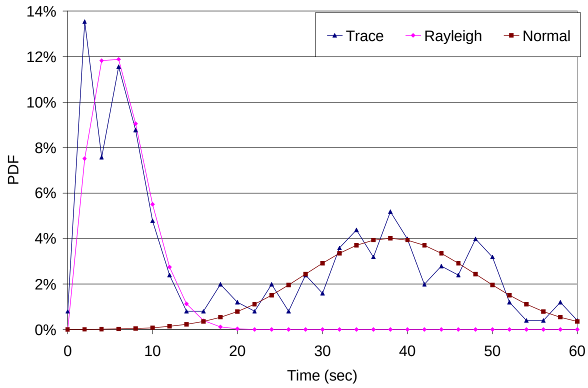

Figure 3 Inter-arrival Time Distribution for WAP-based News Site (yahoo)

time to about 20 seconds. The reading time is normally distributed with mean of 38 seconds and a standard deviation of 10 seconds. Most web models proposed in the literature have exponential inter-arrival times for components on a page and an exponential or gamma distribution for time between pages, and our web statistics for the newsreading scenario broadly agreed with such a distinction between downloading pages and reading them, although the distributions are different.

The file size distribution showed a little more variety and was a little more clustered around the mean than in the 'look-up' scenario, as would be expected given the grater variety of content. However, it still cannot really be aid to conform to any distribution. The mean is about the same as before (1000 bytes).

5. AGGREGATE TRAFFIC SIMULATOR

In order to evaluate the characteristic of WAP traffic, first of all, a traffic model was built in the network simulator ns to generate simulated WAP traffic. The resultant traces were then studied through aggregation over different time scales and the degree of self-similarity and long range dependence was estimated.

A simple fixed network consisting of two wired nodes and two base station nodes was created. The nodes were inter-connected as shown in the network topology diagram below in Figure 4.

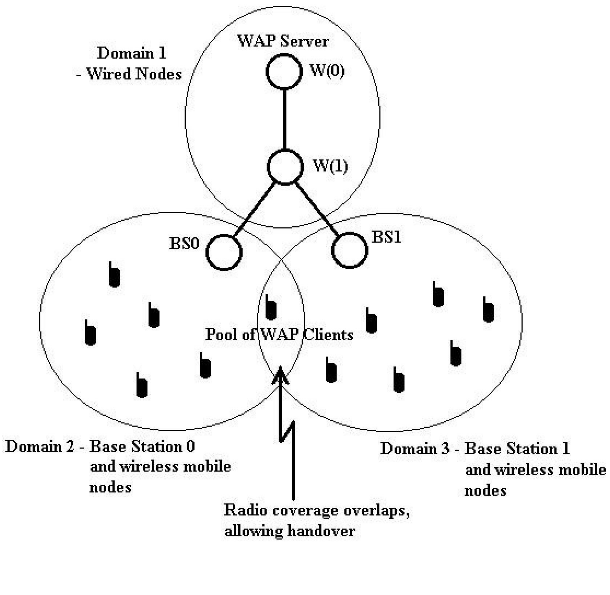

Figure 4 Simulation Testbed Network Topology

The two base station nodes are positioned such that they are overlapped at the edge, making it possible for the wireless nodes to handover from one base station to another while they are roaming in the area. A topological area, roughly about the size of the combined radio coverage of the two base stations, is also defined, to ensure that all the wireless nodes being simulated are within the coverage of at least one base station, and hence will be able to communicate with the wired node at all time. We have adopted the approach of random motion for all the wireless nodes, meaning that they will be roaming around within the defined topology with their starting locations, destinations and speeds being randomly generated by the simulation at each iteration. The capacities of the links were configured to ensure that there was no smoothing of the traffic due to capacity constraints, as this would affect our results in terms of traffic pattern.

In order to verify the WAP traffic model built using ns, two other traffic models, one for Web traffic and the other for packet speech traffic, were also created in ns to allow for aggregate traffic generation. These other sources also allowed for validation of the modelling approach, since real-life Web and speech traffic traces are easily accessible, and the results obtained through the ns simulations could be compared with them. In fact, there does not exist one single set of Web traffic parameters from one single study that we could fully adopt to be applied in ns. Instead, the individual traffic parameter required for the model was allowed to take on values from results of several studies [5,6,7] which best fit their respective meaning. A summary of all the parameters used to simulate the Web traffic model is depicted below in Table 1.

	Distribution	Value
Session Size	Lognormal	Mean 2.3, SD 3
Page Inter-arrival Time	Pareto	Mean 35s, Shape 1.5
Page Size	Pareto	Mean 5.55 objects, Shape 2.43
Object Inter-arrival Time	Exponential	Mean 0.9 sec
Object Size	Lognormal	Mean 2.07, SD 1.318
TCP Packet Size	Constant	536 bytes

Table 1 Web Traffic Parameters

A packet speech model was also constructed. Speech traffic is usually characterised in terms of voice bursts, implying that it is consisted of bursts of voice separated by periods of silence. The length of both the voice bursts and the silence periods exhibit an exponential decaying distribution, with the earlier having a mean of 1 second while the latter a mean of 1.4 second. Therefore, speech traffic can simply be considered as an exponential ON/OFF process.

Self similarity in the aggregate traffic was evaluated using an estimator implemented in MATLAB based on discrete wavelet decomposition proposed by Veitch and Abry [3] was employed. The concept of the employed estimator was that, after a discrete wavelet transform was performed on the input series, a linear fit which best matched the transformed series has to be found. The slope of the resulting line gives an estimation of the Hurst parameter.

6. RESULTS

In order to fulfil the requirements for both the initial model verification and the actual evaluation of WAP traffic characteristics, various scenarios were established and simulation runs were conducted to obtain the necessary traces for investigation. The scenarios considered were:

- Web only traffic (for verification)
- Speech only traffic (for verification)
- WAP only traffic

♦ Combination of Web and Speech traffic
♦ Combination of Web and WAP traffic
♦ Combination of WAP and Speech traffic
♦ Combination of Web, Speech and WAP traffic

The simulated WAP traffic was aggregated into various time frames to roughly illustrate the existence or not of self-similarity. After that, the Hurst parameter estimation program was then utilised to give a more precise indication of the self-similarity property of WAP traffic. The corresponding aggregation plot and log-scale graph for WAP only traffic were shown below in Figures 5 and 6 respectively.

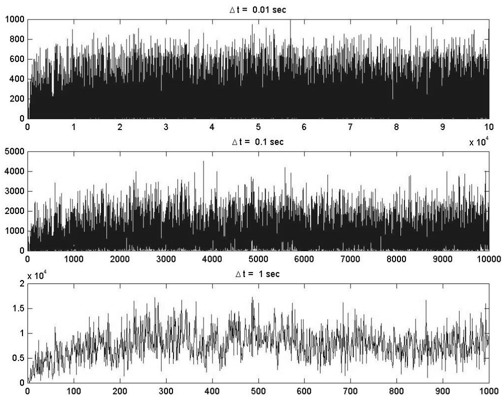

Figure 5 Sample Aggregation Plot for WAP Only Traffic Scenario

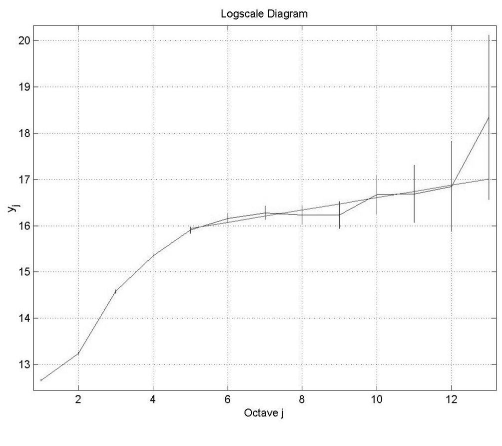

Figure 6 Sample Log-scale Graph for WAP Only Traffic Scenario

From the degree of burstiness of the signal depicted in Figure 5, we could predict that WAP traffic was indeed slightly self-similar. This is confirmed by the wavelet based estimator. The average value of the Hurst parameter estimated by the program over 20 simulation runs was calculated to be 0.59, where a value above 0.5 indicates self-similarity. This compares to Hurst parameters of 0.39 for speech and 0.85 for web, which is line with expectations. Actual traffic traces captured from Web browsing activity exhibits a Hurst parameter in the range between 0.76 and 0.83 [4].

Sample aggregation plots for web and speech traffic are shown in figure 7 and 8 respectively.

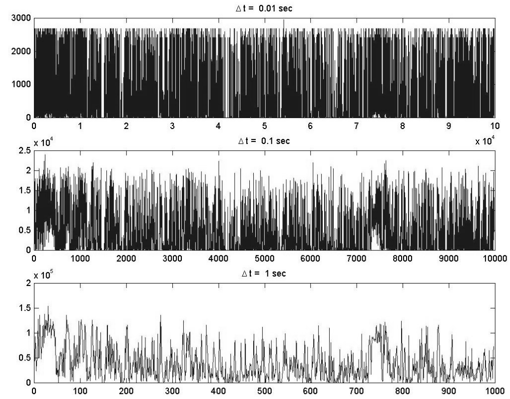

Figure 7 Sample Aggregation Plot for Web Only Scenario

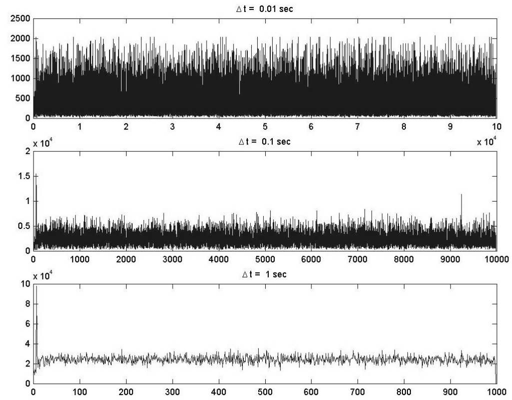

Figure 8 Sample Aggregation Plot for Speech Only Traffic Scenario

Various proportions of web and WAP traffic were combined and the aggregate traffic analysed, with the WAP proportion varying from 40 to 80% of the total traffic (measured in terms of bytes transmitted). A typical aggregation plot for the Web/WAP scenario is shown in Figure 9.

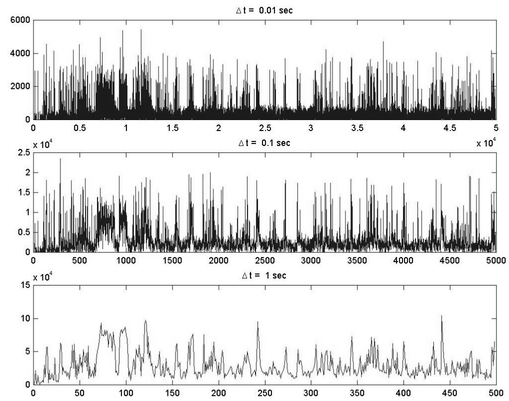

Figure 9 Sample Aggregation Plot for Combination of Web and WAP Traffic Scenario

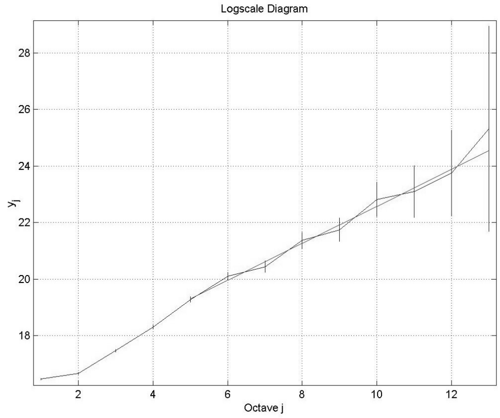

Figure 10 Sample Log-scale Graph for Combination of Web and WAP Traffic Scenario

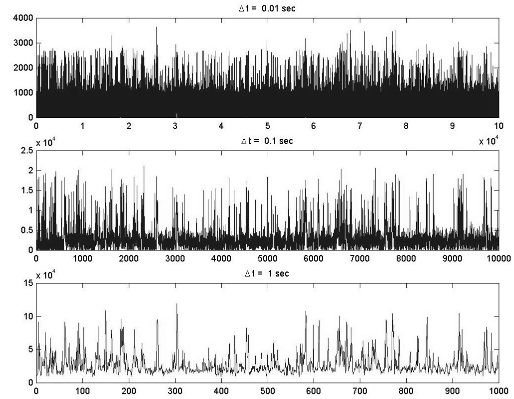

Figure 11 Sample Aggregation Plot for Combination of Web, Speech and WAP Traffic

The aggregation plot clearly illustrates that the combined traffic still exhibits self-similarity, which was confirmed by the Hurst parameter as obtained via the log-scale graph in Figure 10. The Hurst parameter for this particular simulation was estimated to be 0.826.

Table 2 shows the variation in Hurst parameter with diffferent proportions of web and WAP traffic. With the proportion of WAP traffic increasing all the way up to three quarters of the total traffic, the estimated Hurst parameter only dropped slightly by approximately 0.06, which was considered to be insignificant in regards to the degree of self-similarity of the combined traffic. Traffic with Hurst parameter of 0.85 and 0.80 would be considered as equally self-similar. In other words, WAP traffic does not seem to be “helpful” in terms of lessening the problem of self-similarity.

Web	WAP	Average Hurst Parameter
25%	75%	0.80
39%	61%	0.81
47%	53%	0.82
59%	41%	0.86

Table 2 Average Hurst Parameter for Different Combinations of Web and WAP Traffic

Similar results were obtained for mixtures of WAP and speech traffic. The addition of speech traffic reduced the Hurst parameter slightly to 0.56 from its original value of 0.59.

Simulations were also run with all three traffic types with various contributions from each traffic type, with the percentage of Web traffic ranging from 22% to 54%, that of speech from 27% to 53%, while the share of WAP traffic ranges from 13% to 40%. As an example, a single iteration from the pool of simulation runs was identified to have a ratio of Web to speech to WAP traffic volume being 35% : 32% : 33%, and its aggregation traces and log-scale graph were shown below in Figures 11 and 12 respectively.

It is quite obvious from the persistence of burstiness in the above aggregation plots that a combined load with approximately equal share of Web, speech and WAP traffic exhibit a degree of self-similarity not much different from that of a pure Web traffic source. This observation was verified by processing the aggregated trace with the wavelet estimator. The Hurst parameter for this sample was estimated to be 0.819. The results from each set of runs for each traffic split are summarised below in Table 3.

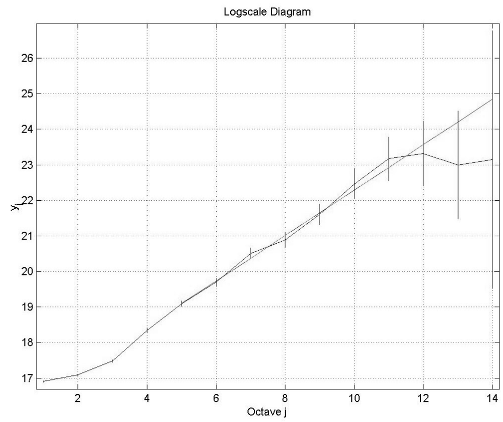

Figure 12 Sample Log-scale Graph for Combination of Web, Speech and WAP Traffic

Web	Speech	WAP	Hurst Parameter
20%	36%	44%	0.74
27%	35%	38%	0.78
26%	36%	38%	0.81
25%	39%	35%	0.83

Table 3 Average Hurst Parameter for Different Combinations of Web, Speech and WAP

7. CONCLUSIONS

Our results show WAP traffic varies significantly from web traffic, particularly due to the way it is accessed. This means that modifications to web based models are unlike to model WAP traffic satisfactory. Of particular note is that even though the page sizes are significantly smaller, interarrival time is increased due to the reduced user interface increasing reading time.

Note that the nature of the experiments means that the results will be affected by the user interface, and so would not be representative of WAP traffic on a device with a different interface such as a pen based one. Reading and scrolling times are also likely to be dependent on the screen size, although the one used here was fairly typical of a WAP-enabled GSM phone.

WAP traffic itself is self-similar, but not significantly so. When aggregated with web traffic, it does not greatly change the high degree of self-similarity present in that traffic. A summary of the simulation runs being conducted, as well as the corresponding traffic characteristics in terms of the self-similarity indicator, the Hurst parameter, is presented below in Table 4.

Scenarios	Proportion of Individual Traffic	Average Hurst Parameter
Web Only	-	0.85
Speech Only	-	0.40
Web & Speech	Web: 40% - 78% Spch: 60% - 22%	0.81
WAP Only	-	0.59
WAP & Web	Web: 20% - 66% WAP: 34% - 80%	0.82
WAP & Speech	WAP: 26% - 74% Spch: 74% - 26%	0.56
Web, Speech & WAP	Web: 22% - 54% Spch: 27% - 53% WAP: 13% - 40%	0.79

Table 4 Summary of Overall Simulation Results

Simulation results from the Web only model suggested that Web traffic on its own is highly self-similar, as indicated by its Hurst parameter in the order of 0.85. This value corresponds quite well with other results already published in literature [4]. In fact, it is this high degree of self-similarity of Web traffic, together with the fact that Web traffic constitutes for a majority of the overall internet traffic nowadays, that has caused the infamous problem that it is extremely difficult to provision sufficient resources to handle internet traffic both reliably and efficiently.

The speech only model agrees with the generally accepted theory that speech traffic itself does not exhibit self-similarity as suggested by its estimated Hurst parameter of approximately 0.4. It is should be noted that in the simulation of speech traffic, packet switching has been assumed from service such as Voice over IP rather than circuit switching.

Speech had a similarly small effect on web self-similarity, reducing its value to 0.81, so 'diluting' web traffic with non-self similar speech traffic does not reduce its self similarity. This could be expected, since over the longer timescales of interest, the underlying speech traffic acts as a constant and will not affect the other characteristics of the traffic. An exception would be where the additional speech traffic increased the traffic on the system and resulted in queuing. Since web and WAP traffic can be queued, the increase in traffic would result in a smoothing effect. Our simulations were designed so that it was operating well below this point so that the offered traffic was measured.

A similar argument could be used to explain why the relatively non-self-similar WAP traffic has little effect on the high degree of self-similarity present in web traffic.

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