Simulation Study of the Effect of Proposed Parameters of Some Well Known Algorithms for Wireless Networks

M. M. Elgazzar
R & D Department
Cairo, Egypt
m_elgazzar1961@yahoo.com

***Abstract*—This paper proposes a new designing parameter for scheduling algorithms for IEEE 802.16-2005 Broadband Wireless Metropolitan Area Networks in TDD mode. While many researchers focuses on the main QoS parameters, Maximum sustained rate(MST), minimum reserved rate, delay and jitter, this research focus on burst window size which is a which is a subjective parameter driven from the MST.**

In this work, a detailed simulation study is carried out for the effect of proposed parameter of some well known algorithms such as Proportional Fairness (PF), Round Robin (RR), and Strict-Priority. Analyses and evaluation of the performance of the schedulers to support the different QoS classes is given as well. The simulation is carried out via the Opnet modeler simulator.

***Keywords*— QoS, Opnet, OFDMA, Scheduling Algorithms, WiMAX**

I. Introduction

Broadband wireless access (BWA) systems, [1][2] are very flexible and easily deployable high-speed communication systems. BWA systems complement existing last mile wired networks such as cable modem and xDSL. IEEE 802.16 group aims to unify BWA solutions [1]. A technical overview of IEEE 802.16 is provided in [1][3]. The objective is to have an efficient use of radio resources while serving different types of data flows. These flows can have different constraints such as minimum traffic rate, maximum latency, and tolerated jitter.

The IEEE 802.16-2005 standard supports three different physical layers: 1) Single Carrier, 2) OFDM/TDMA and 3) OFDMA [1]. OFDMA physical layer is the most efficient and complex one [4]. In OFDMA each substation (SS) can receive some portions of the allocation for the combination of time and frequency so that the channel capacity is efficiently utilized. OFDMA outperforms the OFDM & SC [4]. This research focuses only on OFDMA.

To support the different types of traffic with their various requirements IEEE 802.16-2005 defines five QoS service classes: Unsolicited Grant Scheme (UGS), Extended Real Time Polling Service (ertPS), Real Time Polling Service (rtPS), Non Real Time Polling Service (nrtPS) and Best Effort Service (BE).

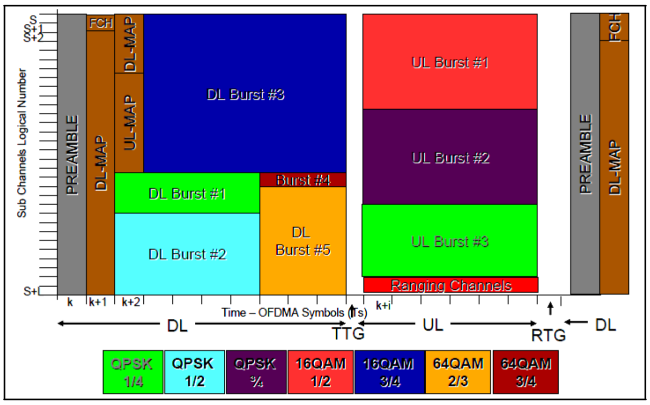

Figure 1: IEEE 802.16 OFDMA frame structure

UGS is designed to support real time data stream consisting of fixed size data packets issued at periodic intervals such as E1/T1 and voice over IP without silence suppression. The main QoS parameters are maximum sustained rate (MST), maximum latency and tolerated jitter (the maximum delay variation.

rtPS: This service class is for variable bit rate (VBR) real-time traffic such as MPEG compressed video. Unlike UGS, rtPS bandwidth requirements vary and so in this service, the BS provides periodic unicast (uplink) request opportunities, which meet the flow's real-time needs and allow the SS to specify the size of the desired grant. The QoS parameters are similar to the UGS but minimum reserved traffic rate and maximum sustained traffic rate need to be specified separately [4].

ertPS: This service class is designed to support VBR applications that have data rate and delay requirements, like the case in VOIP without silence suppression. The QoS parameters are the same as those in UGS [5].

nrtPS: This service class is for non-real-time VBR traffic with no delay guarantee. Only minimum rate is guaranteed. In the nrtPS scheduling service, the BS provide unicast uplink request polls on a 'regular' basis, one second or less, which guarantees that the service flow receives request opportunities even during network congestion.. In addition, the SS is allowed to use contention request opportunities. File Transfer Protocol (FTP) traffic is an example of applications using this service class [4].

BE: This class is designed to support data streams for which no minimum service guarantees are required, like the case in HTTP traffic. The BS does not have any unicast uplink request polling obligation for BE SSs. Therefore, a long period can run without transmitting any BE packets [5]

In IEEE 802.16-2005, the BS (Base Station) centrally allocates the channels in different slots to different SSs (Subscriber Stations) for uplink and downlink. SSs in turn allocate these resources to the various connections they are supporting at that time. The process in the MAC access layers which is responsible for resource allocation is called the scheduling process. Unlike other parts of IEEE 802.16, scheduling was left for research to specify it. The optimal scheduling algorithm is still in open research area [6][7], and [8]. In this research a focus is given to the effect of some parameters on the different scheduling algorithms.

The remainder of this paper is organized as follows. Section II provides a review for relevant work, simulated schedulers and problem formulation. In section III a discussion for the need of the proposed parameter. Section IV describes setup of the simulation environment Section V shows the results and output of simulation of the effect of the proposed parameter of different algorithms. Concluding remarks and directions for future work are given in section VI

II. RELATED WORK AND PROBLEM FORMULATION

A. *Related work*

Recently published scheduling techniques for WiMAX can be classified into two main categories: channel-unaware schedulers and channel-aware schedulers [4]. Channel-unaware schedulers use no information of the channel state condition in making the scheduling decision. The design of those schedulers varies based on the ultimate goal of the scheduler like, maximizing throughput or fair allocation of resources between different SSs. However, the main challenge faces researches, is the distinctive characters of each of the QoS classes. No single queue algorithm can handle all different types of parameters constrains simultaneously. For instance, no published researches show how to handle jitter over WiMAX, and most researches focuses on throughput rate or delay[4].following are some of channel-unaware schedulers which were tested in this research:

Strict-Priority Queue: In strict Priority when packets arrive at the interface, they are firstly classified and then line at their separate queue end according to their classes. When the packets are transmitted, those in the queue with higher priority will be transmitted first and those in the lower priority queue will not be treated until there's no packets left in the higher priority queue.

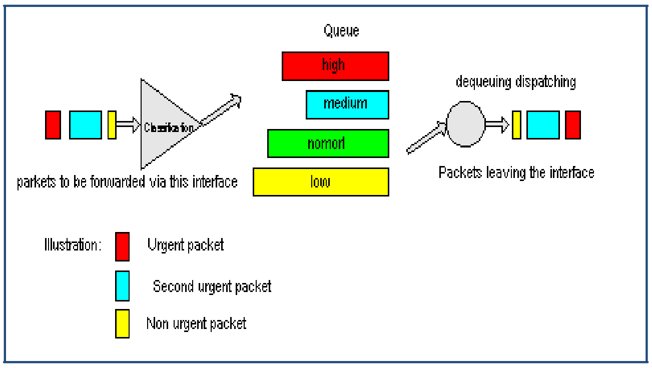

Figure 2: Strict-priority scheduling

Round-Robin (RR) schedules: RR serves multiple queues in ring mode. If the queue on which RR is performed is not empty, the scheduler takes one packet away from the queue. If the queue is empty, the queue is skipped and the scheduler does not wait.

Deficit Round Robin: With MDRR configured as the queuing strategy, non-empty queues are served one after the other, in a round-robin fashion. Each time a queue is served, a fixed amount of data is dequeued. The algorithm then services the next queue. When a queue is served, MDRR keeps track of the number of bytes of data that was dequeued in excess of the configured value. In the next pass, when the queue is served again, less data will be dequeued to compensate for the excess data that was served previously. As a result, the average amount of data dequeued per queue will be close to the configured value

Proportional Fairness (PF): Proportional fairness [13] is a compromise-based scheduling algorithm. It's based upon maintaining a balance between two competing interests: Trying to maximize total wireless network throughput while at the same time allowing all users at least a minimal level of service. This is done by assigning each data flow a data rate or a scheduling priority (depending on the implementation) that is inversely proportional to its anticipated resource consumption

Max-min fairness: The principle of max-min fairness is to allocate network resources in such a way that the bit rate of a flow cannot be increased without decreasing the bit rate of a flow having a smaller bit rate. Max-min fairness is uniquely defined by the following water filling procedure:

1. Start from a bit rate equal to zero for all flows
2.Increase the bit rate of all flows at the same speed until the bit rate of some flows is constrained by the capacity set; freeze the bit rate of these flows;

3. Apply step 2 repeatedly to non-frozen flows until the bit rate of all flows is constrained by the capacity set.

Since different classes have different requirements, many recent researches use Intra-class scheduling, where each class has a distinctive resource allocation mechanism that matches the requirements of the quality of service. Relation between inter classes is organized based on class-priority, where classes are served in the following order UGS, ertPS, rtPS, nrtPS, BE.

B. Problem formulation,

In this research, a special focus is given to burst window size. Were we study how many bytes can be sent sequentially for one session, and the effect of this window size on the performance of the algorithm as well as the efficiency of the transmission of different sessions including throughput, latency and Jitter.

III. PROBLEM DISCUSSION

In many access media like Ethernet, token ring, and fiber links there are no prioritization or QoS parameters characteristics of the connected terminal, since in these access methods, access speed is much higher than maximum transmission packet size, and that all terminals have the right to access the media equally at any time, and the interleaving between different packet occurs at very short intervals. However in other media with lower speeds like frame relay,

IV. SIMULATION MODEL

The overall goal of the simulation model is to analyze the behavior and performance of the proposed algorithm in a congested uplink domain The simulations have been performed using Opnet Modeler version 15.0 [14].The important parameters used to configure the PHY and MAC layers are summarized in table (1)

The simulation assumes error-free channel since it makes it easier to prove assurance of QoS. Maximum theoretical capacity of the upload system is estimated as follows:

Upload Data rate = *number of uncoded bits per data symbol * total number of upload symbols*

In this model: *number of encoded bits per data symbol, = 560 * 6 *3/4 = 2520 bit*, where 560 is total number of data sub carrier for upload PUSC usage mode.

Data rate *=2520*12 symbol per frame *200 Frame= 6.048Mbps*

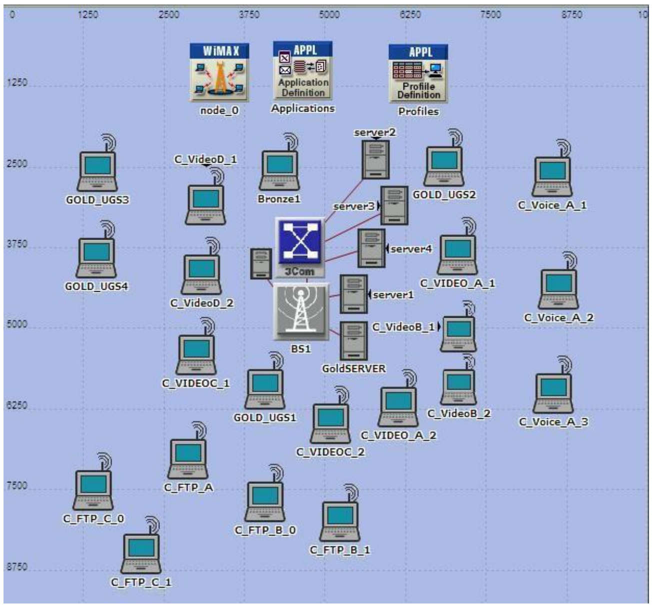

Figure 3 System model implementation in Opnet

Since the simulated rtPS and nrtPS SSs are using polling service, which uses BPSK modulation at1/2 coding rate, it can be assumed that the idle average throughput of upload bandwidth is 5.5Mbps. *So,* the congestion criteria in this model is achived via increasing the total maximum sustained rate requirements of all substations to exceed 5.5Mbps

Model	**Point to Multipoint**
WIMAX channel bandwidth	= 10 MHz
Frame duration	5ms
Symbol Duration	102.86 Micro second
N	28/25
Delta_f	10.94khz
Number of sub carriers	1024
Frame structure	
Preamble symbols	1 symbol
Dublexing technique	TDD
Base Frequency	2.5GHZ
TTG	106 micro second
RTG	60 micros second
UL/DL Boundary	Fixed
UL sub frame size	= 12 slot
DL sub frame size	= 32 slot
Initial ranging	= 2 slot * 6 sub channel
Contention slot	= 1slot * 6 sub channel
Initial coding rate	¾
Initial modulation	64QAM

Table 1: Main parameters of the simulation model

The simulation environment consists of one BS and (20~26) SSs operating in IEEE 802.16 PMP mode. There will be one service flow between each SS and the BS. Traffic flow classes and their configuration are indicated in Table (2). The congestion condition in the system is conducted via increasing throughput load on the BS by increasing number of flows of a specific type (for example video priority traffic).

Class	**Max. rate Kbps**	**Min. Rate kbps**	**Pri**	**Traffic Type**	**No of SS**
UGS	100	100	N/A	Video	2
RTP	384 ~600	200	20	Video	2~8
RTP	384	200s	10	Video	2
nRTP	384	200	20	FTP	1
nRTP	384	200	10	FTP	2
nRTP	200	100s	10	FTP	2
RTP	200	100	20	Video Conf.	2
RTP	200	100	10	Video Conf.	2
RTP	60	40	20	VOIP	3
BE	384	N/A	N/A	HTTP	2

Table2: Service flows

V. RESULTS

In this section, the output of simulation is shown and analyzed

The first step to assess the burst window size is to test is affect on throughput of single session as shown in Figure (4). This figure studies the affect of Burst window size in three cases: 1) Burst window size equals to 1 S, which means that the whole sent traffic sent sequentially at any time might equals to the average throughput rate per 1 S. 2) the second case shows the a window size of 20 ms, which means that the sequential sent traffic might 1/50 of average throughput per minute. 3) The third case shows a window size of 1/200 of the throughput rate per, which makes the length of the window size equals to 5ms, which is the frame length in this case, taking into consideration that this small window size permits the sent packet to reach the maximum packet size, but credit it from the following frames. In other words, if the burst window size is 500Byte, while the packet size is 1500byte, the first frame will send the whole packet but the following frames will not sent any packets till the sum of skipped burst windows will reach 1500byte

In Figure(4), we can see that in the first case where the burst window length is only one frame length, the session throughput is smooth and almost reach the out, its nominal throughput,400k in this case, however, the throughput is slightly smaller than the 400 due to , skipping some frames without sending any packets.

The second case, 50 ms, shows a perfect smooth throughput due the flexibility, if the window length which allows the system to send a bulk of data in short periods.

The third case is the window size of one 1 second, it is shown that despite the length of the window is big enough; it has a negative effect, which is the big variation in the throughput. This is due that the window is allowing all the packets to be sent over a short period, however the total rate limiter, stops the session for further transmission till further traffic is equal to session nominal throughput rate.

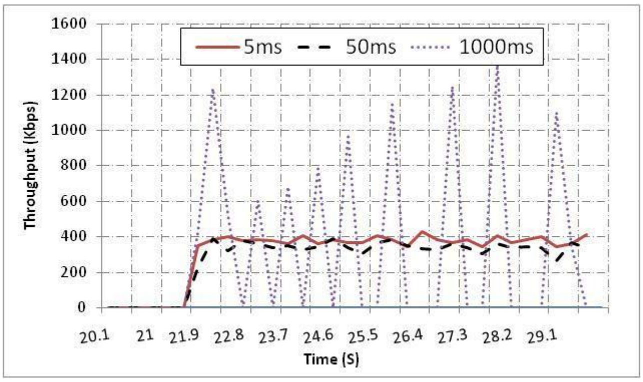

Figure 4: Throughput of a single session under different burst windows

The case of sending a bulk of data for a single session, will not occur when multi-sessions are served in parallel, and the scheduling algorithm will have a great effect on the shape of output as shown in the following figures

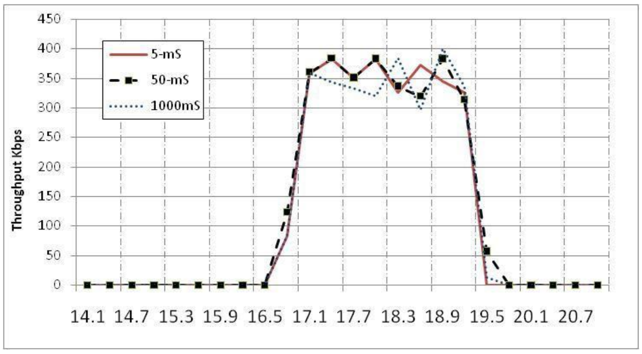

Figure 5: Throughput a session via RR Scheduling

Figure (5) shows the performance of 400K Session among a group sessions, scheduled via the Round Robin Scheduling algorithms in the case of the Burst window sizes. It is shown that in the three cases, the performance of the scheduler is almost the same? The main reason for this, that the RR scheduler picks only one packet from each session, each time it needs to transmit the packet, regardless how much allowance it has for this session.

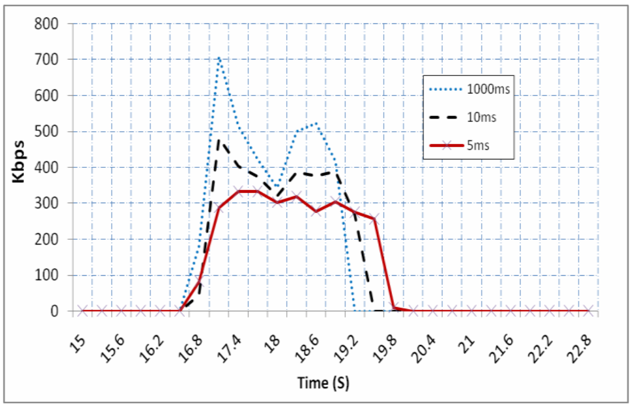

Figure 6: Throughput of a high-priority session via Strict Priority Scheduling.

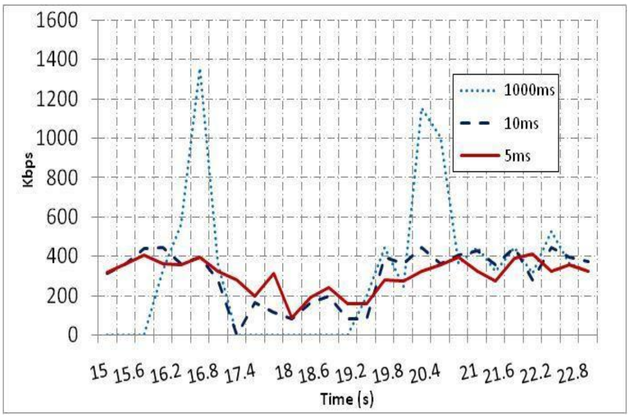

Figure 7: Throughput of a low-priority session via Strict Priority Scheduling.

In Figure (6) a comparison between the Burst window size effects is shown, Where a high-priority session start to send traffic among other low priority sessions. It can be shown the BWS has a great effect on the shape of the throughput. A 1000ms window size will allow the Scheduler to send high throughput of data at sequence, this might be good for the High-priority traffic, however, for low priority traffic it totally starve for a short period, which may have a low effect on the total throughput per minute. Put for sure it will affect the delay and jitter of the low priority session as shown in Figure (7).

Figure (8) shows the throughput of an ordinary session via Proportional Fairness protocol, and Figure (9) shows the throughput of an ordinary session via max- min protocol. Similar to the round robin algorithm, it is shown the BWS has almost no effect on the throughput or behavior of each session,

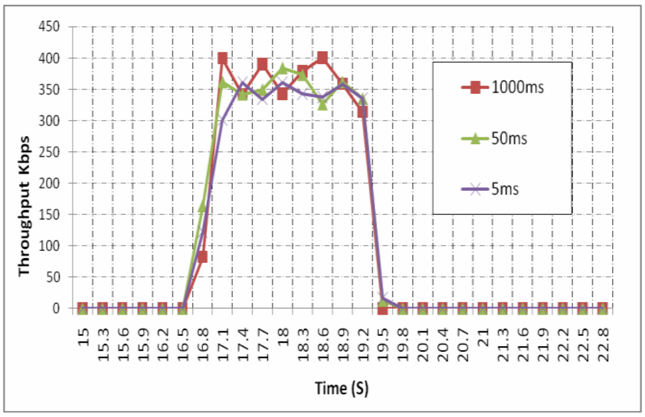

Figure 8: Throughput of a burst session via Proportional Fairness.

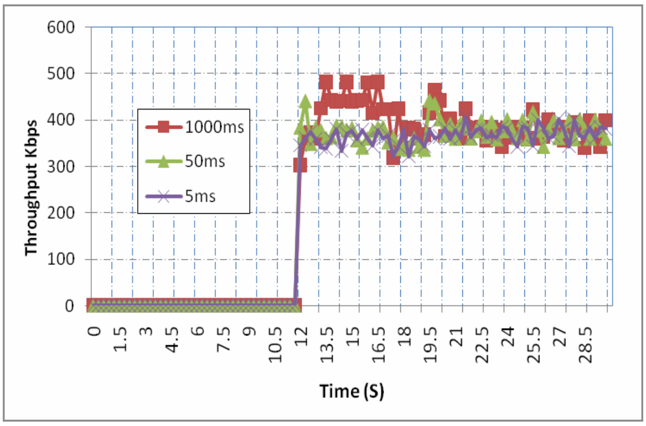

Figure 9: Throughput of a normal session via Maximum Minimum scheduling algorithm

VI. Conclusions

In this paper, a comparison of the effect of the burst window size is give for a group of scheduling algorithm. It is shown. From the results, that for many algorithms, the burst window size has an effect on the performance of most scheduling algorithms in the steady sate case, where all sessions have steady throughput. However for sessions which is in transit states or has a nature of pulse throughput over time the BWS has a high importance on the making a smooth transition over this period that helps to serve not only the pulse session but all the other systems as well. It is recommended based on this research to apply a BWS which is equal to length of 5~10 frames and has a size of 1/10th of the regular throughput of the system

References

[1] IEEE P802.16Rev2/D2, "DRAFT Standard for Local and metropolitan area networks," Part 16: Air Interface for Broadband Wireless Access Systems, Dec. 2007

[2] IEEE 802.16 Working Group on Broadband Wireless Access. http://wirelessman.org

[3] C. Eklude, R. B. Marks, K. L. Stanwood and S. Wang. "IEEE Standard 802.16: A Technical Overview of the wireless MANTM Air

Interface for Broadband Wireless Access," IEEE Communication Magazine June 2002

[4] Chakchai So-In, Raj Jain, Abdel-Karim Tamimi, "Scheduling in IEEE 802.16e Mobile WiMAX Networks: Key Issues and a Survey," IEEE Journal on Special Areas in Communications (JSAC), Vol. 27, No. 2, February 2009

[5] Loutfi Nuaymi, WiMAX TECHNOLOGY FOR BROADBAND WIRELESS ACCESS, John Wiley & Sons,2007

[6] L. Lin, W. Jia, and W. Lu, "Performance Analysis of IEEE 802.16 Multicast and Broadcast Polling based Bandwidth Request," in Proc. IEEE Wireless Communication and Networking Conf., Hong Kong, 2007, pp. 1854-1859.

[7] B. Chang and C. Chou, "Analytical Modeling of Contention-Based Bandwidth Request Mechanism in IEEE 802.16 Wireless Network," IEEE Trans. Veh. Technol., vol. 57, pp 3094-3107, Sept. 2008

[8] V. Alexey, Z. Ying, N. Qiang, and L. Andrey, "Efficient Request Mechanism Usage in IEEE 802.16," in Proc. IEEE Global Telecommunications Conf., San Francisco, CA, 2006, pp. 1-5

[9] Vandana Singh, Vinod Sharma, "Efficient and fair scheduling of uplink and downlink in IEEE 802.16 OFDMA networks", Wireless Communications and Networking Conference, 2006. WCNC 2006. IEEE,

[10] Ahmed H. Rashwan, Hesham M. El-Badawy, Hazem H. Ali, "Comparative Assessments for Different WiMAX Scheduling Algorithms" WCECS 2009, October 20-22, 2009, San Francisco, USA

[11] C. Cicconetti, L. Lenzini, E. Mingozzi, and C. Eklund, "Quality of service support in IEEE 802.16 networks," IEEE Network, vol. 20, pp. 50-55, April 2006.

[12] X. L. Huang, B. Bensaou, "On Max-min Fairness and Scheduling in Wireless Ad-Hoc Networks: Analytical Framework and Implementation", ACM MobiHoc'01, pp. 221-231, Oct. 2001 N.

[13] Ruangchaijatupon and Y. Ji, '"Simple Proportional Fairness Scheduling for OFDMA Frame-Based Wireless Systems," in Proc. IEEE Wireless Communication and Networking Conf., Las Vegas, NV, 2008, pp. 1593-120

[14] www.Opnet.com

.