Advanced Internet Satellite Extension Project

Janet K. Poley
American Distance Education Consortium (ADEC)
Lincoln, Nebraska

Dan C. Cotton
University of Nebraska-Lincoln
Lincoln, Nebraska

Valorie F. McAlpin
University of Maryland
College Park, Maryland

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I. Introduction

The phrase Digital Divide has emerged as a description much like the word diversity as an attempt to characterize a set of varied demographics and situations. In January Steve Cisler wrote in the San Jose Mercury News that digital divide has a nice ring to it, but it is simplistic, insulting to some, and if it has the half life of other techno jargon, it should last no longer than infobahn and techno-realism.

Many of us are increasingly uncomfortable with lumping a lot of important, rich and uncomfortable statistics and information into something called the digital divide. There is real danger that digital divide ends us pushing to the margins or periphery a whole set of important issues related to the drive toward digital, Internet, bandwidth and all else associated with becoming a knowledge society.

Instead of producing fertile ground for the emergence of new ways - we might simply end up with a convergence of those left out. It is difficult to talk intelligently about the situations and applications appropriate for rural poor communities, rich rural communities - Ted Turner is the biggest landowner in rural Nebraska. Inner city neighborhoods are not the same irrespective of location. African Americans, Asians, Hispanics and Indians are converged together only because they are not white or Caucasian. Increasingly, the disabled and even the elderly are considered to be on the other side of this digital divide.

Closer to home, colleges and universities have begun calling application of technology to education asynchronous learning or distributed education. By dropping the word distance from education, we can again forget that not all learners live in wired dorms or fibered suburbs.

II. Concentration of Poverty: Deconcentration of Opportunity

A growing problem of the digital millennium is the increasing polarization between the information haves and have nots. Land-grant universities can be part of the problem or part of the solution. When land grants first began in 1862 and 1890, the U.S. was an agrarian society, and research-based agricultural information was critically needed for the economic well-being of families in rural communities. We have a decreasing number of farms, but there remains a significant number of poor, low-income residents living in isolated rural communities and inner cities, 5.9% of whom do not even have a telephone. As technology continues to develop, the gap between the information haves and have nots continues to widen.

Who are the information haves and have nots? According to a Department of Commerce study, the haves include young, white males with middle to upper incomes. The have nots include the elderly, undereducated, racially/ethnically oppressed, unemployed, physically handicapped, the imprisoned and the rural poor.

Recent reports released by the Department of Commerce, *Falling Through the Net,* (1997) and

The Children s Partnership (TCP), indicate that many people in inner cities and isolated rural areas do not have access to technology or the tools of their more affluent suburban neighbors. A deeper problem is that many poor neighborhoods lack the infrastructure available in more affluent areas. Too often, telephone and cable companies will redline poor, inner city neighborhoods while moving quickly to wire wealthier suburbs with advanced systems. This strategy often leads to a spiral where the lack of investment at the community level leads to fewer economic opportunities for people who live there, resulting in continued poverty making it even less inviting for investors and economic growth. The Office of Technology Assessment (OTA) described the effect as the concentration of poverty and the deconcentration of opportunity.

The TCP report entitled, *Online Content for Low-income and Underserved Americans: The Digital Divide s New Frontier (www.childrenspartnership.org),* examines a critical element of the digital divide debate----relevant content. The technology infrastructure is a necessary but not sufficient ingredient. What kinds of programming content are most interesting to rural, isolated communities or poor inner city communities? Are their interests, needs and concerns the same as the more affluent suburban communities? Through focus groups and interviews, TCP found that underserved adults want to engage in social, cultural and professional activities online with special emphasis on local information about entertainment, jobs, places of worship and educational opportunities. TCP s research also found a number of barriers between the content people want and what is available online. Barriers include a) lack of local information, b) literacy barriers, c) language barriers, and d) lack of cultural diversity.

III. New Teaching and Learning Models

ADEC recognizes that 21st century information technology is driving the development of new teaching and learning models. Constructivist epistemologies, as opposed to the objectivist pedagogies of the industrial age, encourage experiential learning and new ways of knowing or meaning-making. Flexible, learner-centered models are replacing the inflexible sage-on-the-stage, teacher-centered models of the last 100 years. Education is now more democratic than ever, with unprecedented access to information and the power it yields. Yet, without adequate technical and human infrastructure, many of our land-grant institutions are unable to compete in this new knowledge environment, and the gap between the information haves and have-nots continues to widen.

The evolution of teaching and learning can be viewed by examining four generations of distance learning. The first generation is correspondence study whereby printed materials were mailed to students and the only interaction was in returning tests &.. still highly popular with some 4 million homes subscribing to correspondence study. The second generation is multi-media with print. Learners might use a videotape along with a workbook or satellite broadcasts with printed materials. Still very little interaction between the teacher and learner and virtually no interaction among the learners themselves. Third generation models include online learning and web-based courses with a dramatic increase in interactivity and collaboration between and among students and teachers. There is still another generation of teaching and learning just beginning to emerge.

This fourth generation includes Internet2 with virtual reality, simulations, voice recognition, and interactive video.

New teaching and learning models offer high quality learning anytime, anyplace without regard to distance or time. Learning is modular, self-directed, open, flexible, and learner-centered as opposed to teacher-centered models of the past. New distributed learning models focus on active learning, reciprocal teaching and cooperative learning &..building on the students learning style, experiences, and ways of knowing. Learning is interactive and asynchronous rather than the passive, one-way broadcast learning of the past. There is a shift from objectivist, behavioral approaches to constructivist approaches that emphasize critical thinking and constructing new meaning from knowledge based on one s own experience and way of knowing as opposed to accepting knowledge because someone else says that it s true. Students also have unprecedented access to knowledge sources, including industries, peers, and experts throughout the world.

IV. New Research Models: Beyond comparative studies

What kind of research will be needed to help frame evaluation studies on the effectiveness of new learning strategies? Past research has been largely dominated by comparative studies. These studies typically ask the question if there is any difference between teaching with a particular distance technology and face-to-face teaching. These studies have all revealed that there is basically no significant differ ence in learning out comes with distance teaching versus face-to-face teaching. McAlpin s (1997) dissertation research examined factors impacting the academic performance of online students versus face-to-face students and found that there was no significant difference in course grades between the two groups of students. This study, however, revealed some key questions about instructional design and operational definitions of the delivery system. What were the dimensions of the online learning environment? Did the instructor use constructivist, asynchronous, learner-centered approaches or was the learning traditional in its design and simply delivered via technology?

Smith and Dillon (1999) writing in the American Journal of Distance Education propose a framework based on media attribute theory that can be used to classify both media and delivery systems based on research related to learning and motivation. They further posit that the problem with comparison studies lies not in the comparison, but with the media/method confound. According to Smith and Dillon, it is important that comparative studies not only address which technologies were used, but why and how the media and delivery systems were used to support learning and motivation. They provide a framework for defining the variables used in studies that compare delivery systems and alternative distance learning systems.

The Smith and Dillon (1999) framework defines categories of attributes embedded within each delivery system that may support learning in different ways. With technology choices becoming increasingly more complex and with convergence to digital platforms, identification and operational definitions of the attributes of delivery systems play a major role in identifying learning outcomes. For example, one feature of a delivery system is bandwidth. The medium attribute then would be realism. Another feature of a delivery system might be one-way or two-way interaction. The medium attribute would be interactivity and feedback. If the delivery system is synchronous or asynchronous, the medium attribute is immediacy on interaction, which has implications for pacing and responsiveness of the learning design. One feature of the delivery system might be the delivery interface with branching as the attribute with implications for learner control and navigation. This framework can help researchers identify new constructs in their search for answers to 21st century problems of distance learning.

V. The Principle of Common Carriage Depends on Point of View: Open Access: Forced Access

The Telecommunications Act of 1996 enacted a competitive principle embodied by the dual duties of nondiscrimination and interconnection. See 47 U.S.C. s.201 (a) ...s. 251 (A) (1)... Together, these provisions mandate a network architecture that prioritizes consumer choice, demonstrated by vigorous competition among telecommunications carriers.

The consumer federation of America published Principles of Nondiscriminatory Access to Broadband Internet Communications Services, August, 2000. The document states:

> As communications and commerce converge on the broadband Internet, the public right to nondiscriminatory access to communications networks becomes more important than ever. Public policy should guarantee that right, by embracing eight basic principles:
>
> 1. Ban Discrimination
> 2. Maximize ISP Access
> 3. Enforce Nondiscrimination Through Private Action
> 4. Minimize The Anticompetitive Effects of Technical Limitations
> 5. Require Comparably Efficient Interconnection and Nondiscriminatory Operational Support Systems
> 6. Ensure Confidentiality of Customer Information
> 7. Require Subsidy Free, Nondiscriminatory Pricing
> 8. Require Wholesale Relationships Between ISPs and Facility Owners

VI. ADEC - National Science Foundation Project

In late August, the American Distance Education Consortium, an organization of approximately 60 state universities and land-grant colleges, learned that it has been awarded a three-year grant from NSF for the Advanced Internet Satellite Extension Project (AISEP). This $4 million effort will develop and deploy advanced Internet services and technologies over satellite infrastructure for purposes of enhancing research, instruction and learning in a diverse set of institutions of higher education.

This combined effort by ADEC and Tachyon, Inc. will extend the benefits of Internet2 to a broader set of institutions and provide experience with advanced satellite-based Internet technology. The project will be managed by ADEC and led by a core set of ADEC member institutions engaged in the Internet2 project. ADEC bridges the Internet2 community to an extended set of diverse institutions of higher education. Tachyon will provide the technology capable of connecting the Internet2 community to institutions unable to access the Internet2 backbone network because of location.

This project focuses on bringing advanced networking applications to more remote campuses and learning centers. It will enable a broader community to engage in research, create access to remote instruments and data sources, share instructional and learning resources among a more diverse student population and create access by the research university community to cultural and human resources from otherwise inaccessible institutions and extension offices.

This project will work closely with the NSF financed project managed by Educause focused on Minority Serving Institutions. ADEC will also work closely with CAIDA and NLANR, as well as other appropriate partners.

VII. AISEP Goals and Objectives

The primary project goals are to:

1. explore the use of satellite technology to deliver Internet services so as to determine the compatibility of this new technology with services and applications being developed within the Internet2 project; and

2. explore the deployment and integration of distance education applications, including collaborative applications at rural, remote institutions and extension learning centers that have previously been unable to access such technologies.

Research objectives of the project will include but are not limited to:

1. establishment of what constitutes "pretty good Internet" for remote locations;

2. construction of and support for a satellite based IP network;

3. connection of the Tachyon satellite gateway to the San Diego NAP (commodity and Internet2 service providers);

4. provision of Tachyon Access Points to selected ADEC members not accessible via the traditional Internet infrastructure;

5. Investigation of QOS using Tachyon/Internet2 Quality of Service capabilities to enable distance education application;

6. collaboration with NLANR and CAIDA measurement teams to study network

performance;

7. Utilization of QOS to deliver through the Internet including satellite wireless last mile solutions;

8. establishment of requirements to support this type of network;

9. establishment of the parameters for a sustainable business model.

VIII. Need for Project

Dr. Rita Colwell noted in her keynote address to Educause last year that there is a tremendous need for greater research and development efforts in wireless technologies to bring affordable "last-mile solutions." There is further need to integrate these solutions into supportable propositions about teaching and learning applications. Filling bandwidth with digital video without careful attention to design will not improve teaching and learning. A research base does not exist to support the proposition that more bandwidth means more learning.

This project will convene a blue ribbon panel that will also help build a more constructive, theoretically supportable framework for optimizing these systems for learning. John Patrick, IBM, stated recently that the real problem is figuring out how to integrate all the applications in a way that makes sense and how to design the applications so they are simple to understand and able to do what we want them to do.

This past summer the ADEC lead institutions for this program worked closely with Tachyon in pre-testing the Tachyon satellite system. The following describes the pre-test and recorded results:

IX. Pre-Test: June 5-August 4, 2000

Tachyon Access Points were installed at the following university/organizational locations with support from campus project leaders: North Carolina State University; University of California-Davis; University of Nebraska; University of Illinois; University of Maryland; and Washington State University. The Tachyon support team was led by Michael Liebhold - Business Development; and a corps of company technicians. Tachyon provided scheduled access to its three core service levels which include C1 (300K); C2 (800K); and C3 (2MB) service.

X. Tachyon Configuration and Equipment

The Tachyon network is carried on geostationary satellites supporting bi-directional communications. Physical characteristics of the technology feature bursty access to network resources. Given current Tachyon network management decisions, the network supports certain Internet applications very well (i.e., Web, POP3 e-mail, FTP). TAP forward channel speeds are offered in three different configurations: C1 (300Kbps); C2 (800Kbps); and C3 (2Mbps) service, with a return channel of < = 256Kbps service. The return channel of < = 256Kbps is a ceiling established by the FCC. The reverse channel uses a multi-carrier TDMA (time division multiple access) methodology to provide connectionless operation and maximize bandwidth allocation. The Tachyon network employs KU Band service which makes it somewhat susceptible to certain weather degradation (rain fade). Tachyon uses SATMEX transponder services that cover North America, and portions of Central and South America. Tachyon intends to provide global services by 2002, with second and third roll-out phases covering Mesoamerica, South America, Australia, South- east Asia, the Middle East and Africa. Tachyon is not an ISP.

All ADEC TAPs (Tachyon Access Points) access the public Internet via a DS3 connection to UUNET's commercial backbone. The local loop for this DS3 connection is provided by Time Warner, and runs from Time Warner's San Diego POP facility to the San Diego Super Computer Center.

The Tachyon Access Point (TAP) installed at each campus includes a small terminal that connects users to the Tachyon network/Internet. The outdoor unit includes a small satellite dish (<1 meter) and integrated transmit/receive electronics that send and receive satellite data (WSU is using a 1.2M dish). The indoor equipment includes a network server consisting of a PC enclosure with a custom satellite modem connected to local campus LAN equipment via a 10/100BaseT Ethernet interface. The Tachyon network server connects to the outdoor unit via a coaxial cable.

XI. The ADEC/Tachyon Application/Communication Server

A server (Linux-based) supplied by the University of Nebraska on behalf of ADEC for satellite link testing was co-located at the Super Computer center in a Tachyon-leased rack, and sits behind a Tachyon-managed Cisco router. It was configured with Chariot endpoint software to accommodate Chariot testing. It provided the consortium with data collection services in support of general user testing, and a discussion group/sharing capability.

XII. ADEC Institutional Configurations

Each land-grant institution located their TAP on or near their respective campus. Tachyon provided, at their cost, TAP installation services and support. Each campus configuration was somewhat unique, yet together the configurations provided a good opportunity for a variety of different users to access and test the system. Between 120-130 users accessed the network at one time or another, with nearly 30 using the system on a semi-regular basis. TAP S were connected in a variety of configurations.

University of Nebraska: A 10 port VLAN within the University s network.

University of Illinois, Urbana - Champaign: A 15-machine network on a single 10Mb Ethernet physical segment supporting a computer training lab.

University of California - Davis: The UC Cooperative Extension Yolo County office was connected to a 10BaseT hub.

University of Maryland - College Park: A hub connected to three computers at the University of Maryland's State 4-H Office.

Washington State University: The TAP was connected to a single computer on the Washington State University campus. They used a 1.2m dish, the larger dish was needed due to weak signal strength from SATMEX.

North Carolina State University: A hub connected to an NT 4.0 computer and Windows CE Thin Clients (ICA) and PCS as desired/required for testing.

XIII. Test Results

Testing was organized into two categories: (1) programmed testing with specific technical data being collected; and (2) general testing by users.

Programmed testing involved collecting specific statistical data relative to network performance. General testing involved users at institutional sites and activities considered outside the programmed tests.

The University of Nebraska led the programmed testing using Chariot client software that generated specific system performance information (data rates, error rates, and latency). Chariot also was installed on the ADEC/TACHYON server.

A Web form and discussion environment was used to collect both programmed and general test results. Maintaining group communication was key throughout the testing period. One-hour audio conference calls were scheduled each Friday morning from 11 a.m. to noon CDT throughout the test. The calls kept people informed, monitored progress, and discussed technical issues.

A. Programmed Test Results

1. Availability - WHATSUP Summary:

   UNL used a product called WHATSUP (http://www.ipswitch.com/) to monitor the Tachyon network uptime. WhatsUp is an inexpensive graphical network monitoring tool that initiates both visual and audible alarms when monitored network elements do not respond to polling. It will even notify you remotely by digital beeper, alphanumeric pager, or e-mail!

A WHATSUP monitor was placed on a test computer (host77) on the Tachyon net. This WHATSUP program monitored the ADEC server at Tachyon, every 15 seconds. This test basically checked the availability of the Satellite network. A WHATSUP monitor was also placed on a computer in the UNL main computer room. It monitored the ADEC server, the test computer (host77), and the RAQ test unit (used for Chariot testing). This test depended more on Internet availability as the pings traveled from UNL to the Internet, to Tachyon, and then to the Satellite and down.

The results through July 28, 2000 were as follows:

Tests from the host77 test computer running WHATSUP:

PC	ADEC Server
Uptime %	97.93 %
Avg. Delay	1174 ms.
Max. Delay	1249 ms.
Min. Delay	647 ms.

The delay times indicate the amount of time in milli-seconds, that it took the ping to travel from the host77 computer running WHATSUP to the ADEC server at Tachyon and back.

Tests from UNL Computer room WHATSUP monitor:

PC	ADEC Server	RAQ computer	host77
Uptime %	99.42 %	97.70 %	97.72 %
Avg. Delay	98 ms	1292 ms	1305 ms
Max. Delay	3836 ms	9774 ms	5487 ms
Min. Delay	60 ms	591 ms	587 ms

The delay times indicated above indicate the amount of time, in milli-seconds, that it took the ping to travel the route from the UNL main WHATSUP computer to the three listed computers, and back. The pings to the ADEC server in this case were not via the Satellite network, but via the Internet. The pings to the RAQ and host77 were via the Satellite.

2. Network Performance Tests:

Network Performance tests were conducted using a product called Chariot by NETIQ http://www.netiq.com/. The following is a brief description of the tests run:

Filesndl and Filesnds

These scripts emulated sending a file from Endpoint 1 to Endpoint 2, and getting a confirmation back. Filesndl sent more data per session than did the Filesnds.

The default file size was 100,000 bytes.
POP3
This script emulated receiving a POP3 type mail file from Endpoint1 to Endpoint2.
The default file size was 1000 bytes, with a 20 byte header. The default data type for the e-mail message was NEWS.CMP.
Realaudio
The Realaudio script emulated the RealAudio application that multicasted audio content from a multimedia CD-ROM. The send data rate defaulted to an average rate of 80kbps.
Realmedia
This script emulated a RealNetworks server streaming a combined audio and video file. The send data rate variable defaulted to an average of 300kbps.

(See Appendix 1 for the table associated with the following notes)

Notes on the Performance Tests:

" The Performance tests were conducted at different times of the day and on different days during the test period, in order to get a better overall view of the performance of the Tachyon network. Tests were generally performed during the 8-5 workday.
" Ten samples were taken of each test during the C1 service level, 6 for the C2 level, and 4 samples of each were taken during the C3 service level.
" The Average Transaction rate was the number of transactions completed per second.

Observations on the Performance Tests:

" The baseline numbers showed good throughout from the RAQ test computer to the ADEC server, in excess of 6 Mbps, nearly 8 transactions per second and very low response time.
" Throughput generally improved for the file sending tests, as the bandwidth increased.
" POP3 and Realaudio performed very well at all service levels.
" Relamedia performed much better at the C2 and C3 levels, as the lost data went from nearly 8% to less than 1 percent. This may be due to a Tachyon policy in effect at the C1 level.
" The Filesnd and POP3 tests are representations of actual transactions. At the C1 level, the Filesnd tests used most of the available bandwidth, but at C2 and C3, they did not. This was most likely due to the transactional nature of the tests, that is, the latency caused by the satellite link most likely played a larger role.
" The realaudio test was set to stream at 80kbps (0.80 Mbps), thus the

throughput did not increase at the higher service levels.

3. TTCP Throughput test results:

Test TCP (TTCP) is a sockets-based benchmarking tool for measuring TCP and UDP performance between two systems. More information on TTCP can be found at: http://www.ccci.com/tools/ttcp/.

(See Apendix 2 for results of this testing. The notes below are associated with this table.)

Observations and notes on the TTCP testing:

- Because no TTCP client was located on the ADEC server at Tachyon, one half of the testing environment was located at a UNL Internet connected computer. This may have introduced delays or slower data rates due the increased complexity.
- Eight TTCP tests were performed at each service level.
- At the lower service levels (C1 & C2), more of the download bandwidth could be used, but at the C3 (2M level, less throughput was seen, that is, only about 55% of the bandwidth was used. The exact cause of this is not known, but may have been due partially to the latency of the satellite, the Internet, or possibly other factors.
- The upload data rate, from the end location up to the satellite and down was very consistent.

B. General Test Results

Project summaries and state feedback were collected to provide the following summary.

FTP: File downloads worked very well across all service level. Small to medium size file uploads worked; however, as expected, large file uploads were problematic. This was due to a full 4MB TAP buffer coupled with the 256K return channel. Tachyon is looking for options to improve large file uploads.

E-MAIL: POP3 email worked very well, occasionally, latency affected the echoing of key strokes. IMAP e-mail was problematic at Maryland, less so at North Carolina State (unknown whether MD and NCSU were using the same version of IMAP). Tachyon intends to optimize for better performance.

WEB: As expected, Web applications worked well across all service levels.

REALNETWORK AUDIO/VIDEO: Audio and video streaming worked well across all service levels.

OTHER APPLICATIONS: H.323 applications did not function very well, but software and hardware configurations, and a lack of standards were factors. While chat, whiteboard applications worked, audio and video were problematic, especially when attempting multipoint conferencing. Slow performance was experienced when testing ICA thin clients. Tachyon has no plans to optimize the network to accommodate the application at this time. One state did successfully use a data conferencing application. Also, states accessed and tested many of their own Web applications and they worked fine.

Tachyon is working on a streaming video service that would work via the 256Kbps return channel. They expect the service to be available by the end of the year. Their business plan will include a metered rate.

XIV. Summary and Conclusions

From ADEC s perspective, the Tachyon technology worked as advertised. Tachyon was easy to work with, interested in feedback and very supportive of the test. Institutions did a good job of testing the network and providing feedback. Key applications worked. The test group believes that C1 level service is a viable product for remote areas with limited or no service. The group was impressed with system performance at the C2 and C3 levels. The test was successful and we are ready to move forward within the parameters described within the proposed NSF program.

From Tachyon s perspective, ADEC organized and managed operations well.

XV. Appendices

XVI. References

Additional attachments can be located at the following URLs:

ADEC/TACHYON TEST SERVER
http://63.103.96.228/

TACHYON GENERAL TESTING USER LOG
http://63.103.96.228/test/

MAIN STREET ECONOMIST
Center for the Study of Rural America - Federal Reserve Bank of Kansas City
http://www.kc.frb.org/RuralCenter/mainstreet/MainStMain.htm (May 2000 issue)

BUSINESS 2.0 - Milking the Net ...for all it s worth
http://www.business2.com/content/channels/technology/2000/06/13/12863

THE COOK REPORT ON INTERNET - Broadband Spread Spectrum Wireless Extends Internet Reach of ISP s and Field Research Scientists....
http://cookreport.com/09.04.shtml

APPENDIX 1

a. C1 (300k) service

Test	Avg. Throughput (Mbps)	Avg. Transaction Rate (#/sec)	Avg. Response Time (sec)	Lost Data %
Filesndl	.282	.358	2.79	na
Filesnds	.258	.322	3.10	na
POP3	0.004	0.398	2.51	na
Realaudio	0.080	na	na	0.03
Realmedia	0.276	na	na	7.78

b. C2 (800k) service

Test	Avg. Throughput (Mbps)	Avg. Transaction Rate (#/sec)	Avg. Response Time (sec)	Lost Data %
Filesndl	0.335	0.426	2.84	na
Filesnds	0.315	0.393	2.58	na
POP3	0.003	0.365	2.78	na
Realaudio	0.080	na	na	0.49
Realmedia	0.298	na	na	0.65

c. C3 (2M) service

Test	Avg. Throughput (Mbps)	Avg. Transaction Rate (#/sec)	Avg. Response Time (sec)	Lost Data %
Filesndl	0.395	0.502	1.99	na
Filesnds	0.337	0.422	2.37	na
POP3	0.003	0.387	2.58	na
Realaudio	0.080	na	na	0.00
Realmedia	0.300	na	na	0.024

APPENDIX 2

Service Level	Avg. data rate download (from satellite)	Avg. data rate upload (to satellite)
C1 (300k)	275.2k bps	239.9k bps
C2 (800k)	701.5k bps	239.7k bps
C3 (2M)	1093k bps	235.9k bps