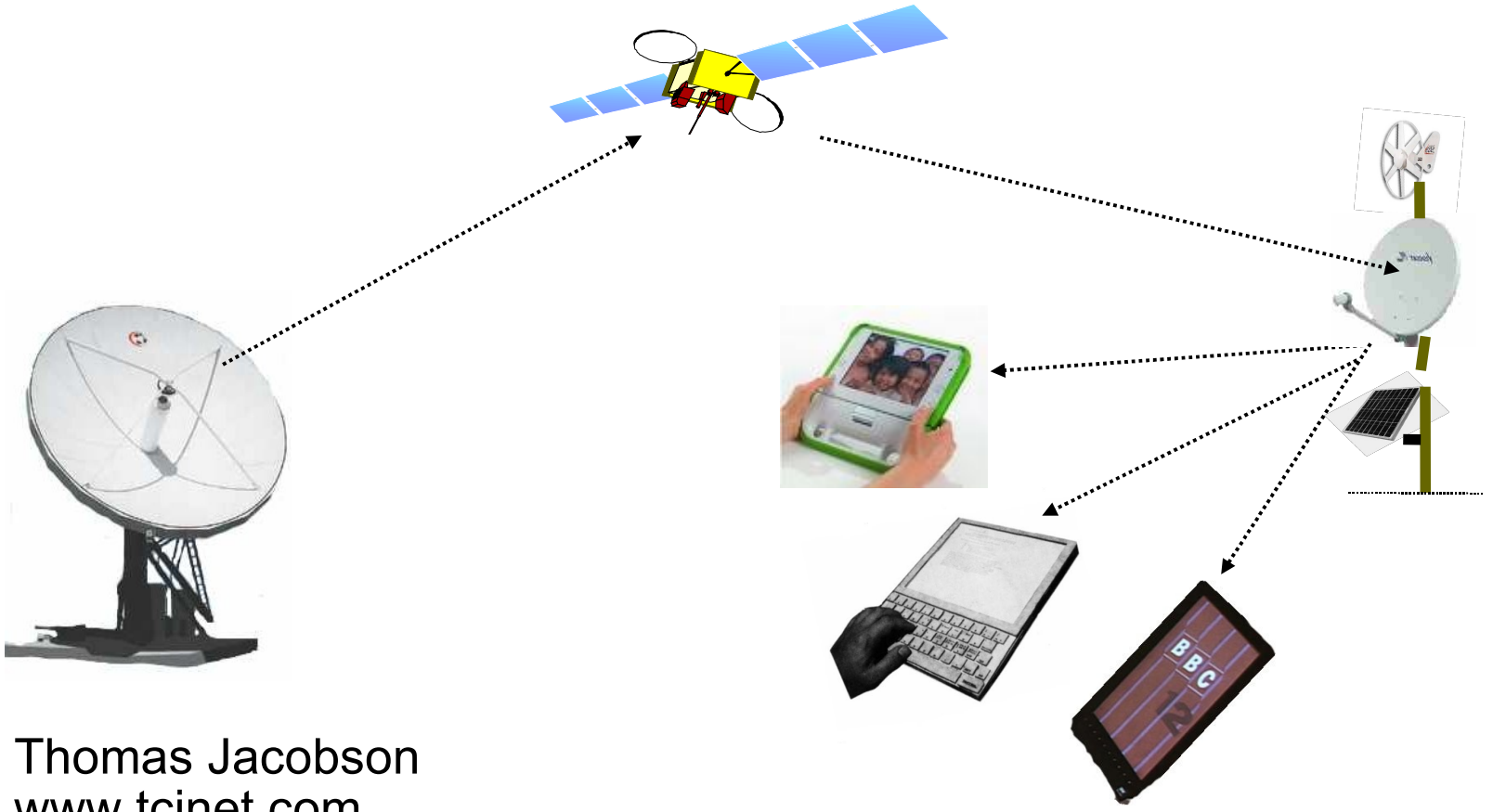
Open Source CDN (RMT w/FEC) to enable low-cost satellite Internet infrastructure for education in remote and developing regions



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The Users

Introduction

- It is axiomatic that ICT facilitates education (and at a minimum can replace printed text books)
- Efforts to provide terrestrial Internet connectivity to remote and developing regions face a daunting array of problems.
- WiMax/WiFi is not well suited to broadcast of large amounts of content, is bandwidth limited, and essentially line-of-sight. L band LEO is too expensive.
- GEO satellites are practically the only means of providing Internet service to many remote and developing areas in the immediate future; but satellites can't really provide interactive Internet bandwidth equivalent to DSL at a reasonable cost.
- Advanced satellites (with spotbeams and using adaptive coding and modulation) will not cover many areas of the developing world for some years.

Why Now?

- OLPC, Classmate, EeePC, etc. deployments have begun.
- Assumption by many that they somehow implicitly include Internet service.
- Belief that without Internet service, these initiatives will fail.
- Misinformed statements made by some about the cost and availability of Internet satellite service.
- Need to provide developers with useful design goals that will help close the gap between whats needed and whats available.

Observations

- Practical school size alternative energy systems (solar, wind, human) supply a maximum of 20W 24/7, and one should design to ½ that.(per John Hutchinson, CTO, Freeplay Energy, and $4/W typical solar panel cost)
- Most satellites in service today cost around $250M to build and launch, and will last for about 15yrs, but have a typical throughput of only about 2GHz. (48ea. 36Mhz Ku transponders)
- A large amount of Internet bandwidth is consumed with SPAM and adult material.
- Ubuntu, OLPC, and others demand open-source solutions free of IPR burdens.

Content

- Examples:
  - eBooks (pdf)
  - Wikipedia
  - Video (mp4)
  - Software Updates
  - Web content to be cached
- A “Podcast” like model:
  - The ability to contribute or co-create empowers and involves individuals; this is an important defence against propaganda, and promotes democratic discourse.
  - A “walled garden” based on metadata?
  - Authenticated content pre-packaged by the source.

Space Segment

- Market Price:
  - Sold by the MHz. A Hz usually yields one to two data bits
  - Is a “commodity” with shallow discounts.
  - Ku price varies by power, footprint, market:
    - Brazil, 52dBW, $3K/MHz
      (Sufficient capacity has kept price low)
    - Africa, 49dBW, $5K/MHz
      (Exploding need and scarcity keep price high)
    - China, India, 49dBW, $2.5K/MHz
      (Rain in Asia makes C band preferable for many applications)
    - Continental US (CONUS), $5K/MHz
- Given that radio spectrum is a finite resource, and satellites are so expensive, how can you get “512Kbps” WildBlue sort of service for $50/mo?
  - Almost all satellite Internet service providers overbook and implement “traffic shaping,” in effect blocking or throttling bandwidth hungry services during peak times. (up to 60:1!!)
  - Don't confuse dedicated point-to-point “trunk” bandwidth with shared end-user service.

Challenge

- Alarming statements:
  - “we connected the village, brought in satellite... and they use Skype every day, the first English word of every kid was Google...” “1Mbps down, 1/2Mbps up”
  - “$1 per student per year”
- The challenge: Come up with solutions that by some magic actually provide such low cost Internet service.

Satellite RO Multicast to the rescue!

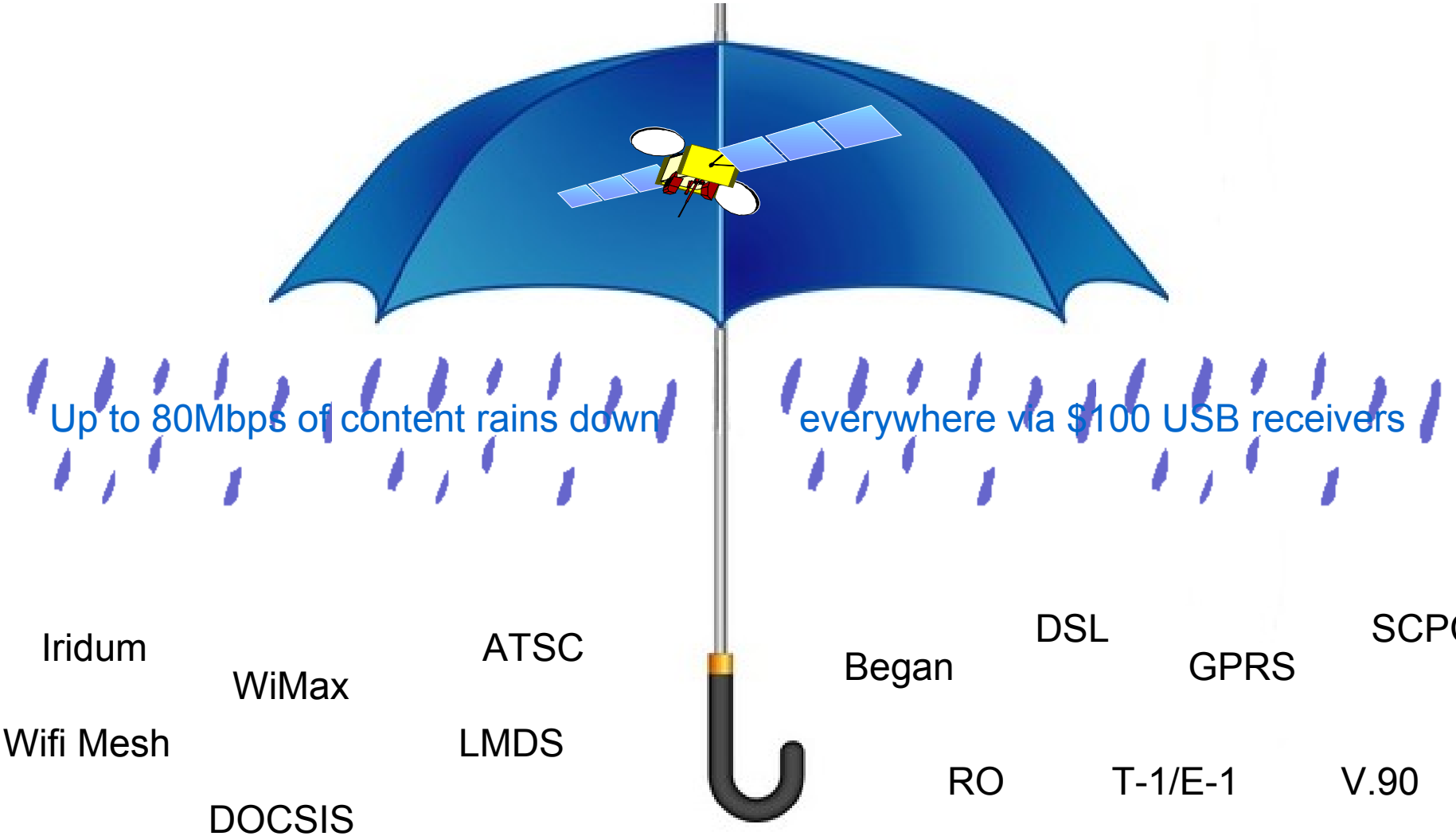
- Where possible, interactive Internet service is always preferable.
- Leveraging the fundamental point-to-multipoint strength of satellites can deliver many of the benefits of two-way Internet service at a fraction of the cost. It is complementary to two-way services when/where available, is a well developed technology that can be deployed ubiquitously and immediately, and can be solar powered at a reasonable cost, if necessary.
- Very simple, robust, low-power Receive Only (RO) technology. Less susceptible to failure because of environmental problems such as unstable power, high temperatures, etc.
- Well developed technology that can be deployed ubiquitously and immediately, and can be solar powered at a reasonable cost, if necessary.
- Mass-produced, very low cost, simple, reliable receivers, easy to swap, replace when stolen, hold as spare, double up for multiple satellites.
- Laws exist in many countries prohibiting restrictions by municipal authorities or housing communes on placement of RO antennas.
- Usually no licences (most countries require licenses for any Tx equipment).
- Signal coding has reached a high level of development. New DVB-S2 link layer Constant Coding and Modulation (CCM) mode BCH/LDPC FEC yields around 30% improvement.
- RO and CDNs can off-load traffic from two-way links

DVB-S2 RO Equipment

- Visiosat SMC consumer RO antenna packaged with LNB

- Technotrend S2 3600 DVB-S2 USB receiver

Umbrella over other connectivity



Pro forma CDN Traffic Budget

(Partial Transponder ~5MHz)

Assumptions

XO Laptops/Students in Country	250000
Students per school	100
	MB/Min
Video Resolution (edutainment): MPEG-4, SD, 1Mbps	7.50
Video Resolution (news): MPEG-4, CIF, 512Kbps	3.84
Video Resolution (podcasts) MPEG-4 QCIF, 128Kbps	0.96
Audio Quality: MP3, mono, 64Kbps	0.48

FEC & overhead	20%
Turns of carousel	2.5
Space Segment $ per MHz/mo.	5000
Bits per Hz	1.5
Simulatinous languages "ML"	5

Daily Traffic	**MB/Day**
eBookmobile	
1000 hypertext eBooks of 10MB	10000
1000 eReports of 1MB	1000
1000 plain text eBooks of 100K	100
News	
Local News MPEG-4, 20mn	77
BBC MPEG-4, 30mn	115
M6 MPEG-4, 20mn	77
Arabic News, MPEG-4, 20mn	77
Asia News, MPEG-4, 20mn	77
UN News MP3 English 30mn	14
UN News MP3 Spanish	14
UN News MP3 French	14
UN News MP3 Local Language	14
Local Paper pdf	10
NYT pdf	10
LeMonde pdf	10
Asia Paper pdf	10
Arabic Paper pdf	10

Weather – ML	
MPEG-4, 5mn, on the hour	463
Edutainment – ML	
Science Show, MPEG-4, 1hr	594
History Show, MPEG-4, 1hr	594
EduQuiz Show, MPEG-4, 30mn	297
Art/Music Show, MPEG-4, 1hr	594
Book Review Show MPEG-4, 1hr	536
Story Time, MP3, 30mn.	72
Chapter a Day, MP3, 1hr	144
Software Distribution & Updates	
System	10
Applications	10
Housekeeping	
Activation messages	0.10
Clean up messages	0.10
Retransmissions	0.10
Wikipedia updates	
2000 ea. 3K articles per day	6
Rolling Refresh (once per month all 5GB)	167
Best of Web	
Selection of popular content (Google Trends?)	1000
Video Podcasts	
1000 Individually requested, 15min ea.	7200
100 Best Video Podcasts, 15mins ea.	1440
Audio Podcasts	
1000 Individually requested, 30min ea.	7200
100 Best Audio Podcasts, 30min ea.	1440

Interactive Multilingual Courseware	
Biology	200
Physics & Chemistry	200
Math	200
Literature	200
History	200
Music	200
Professional & Community Training – ML	
Agriculture MPEG-4, 45mn	281
Journalism MPEG-4, 45mn	281
Technology MPEG-4, 45mn	281
Health MPEG-4, 45mn	281
Teaching MPEG-4, 45mn	281

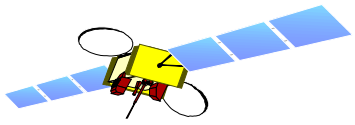
Bandwidth Needed	
Total MB/Day	34598
Mbps to deliver in 24Hrs	3.20
Mbps w/FEC overhead	3.84
Mbps w/carousel	9.61
MHz needed	6.41

$ Per Student Per Month	
Space Segment	0.1281
Uplink CAPEX 5yr @ .02/mo	0.0160
3 FTE & 10% Maint OPEX	0.0667
USB Receivers & Ant 5yr @ .02/mo	0.0200
TOTAL	**0.2308**

NB: This is a back-of-the-envelope *pro forma* budget, and is included to suggest the kind of traffic and bandwidth involved. The actual computation is beyond the scope of this discussion and will be more complex, involving MTU size, fragments, scalable video (SVC), packet loss, multicast grouping, ACK/NACK gains, etc.

School Server “Light”

(Enabled by low-power satellite receiver)



Up to 80Mbps

~65W (peak) Micro turbine

Modified DVB-S2 USB Receiver

IFL

USB

USB

~100GB

13V or 18V 1W

12VDC@3W

5VDC@3W

~50W (peak) Solar

Unreg DC

Unreg DC

USB

18VDC@3W

AES SD card

Server XO

Mesh Repeaters

CDN NACKs

CDN Content

Student XO

Student XO

Student XO

Data Mule for Contribution

10 Watt Power controller (to be developed)

Unreg DC

Unreg AC

or

Emergency manual power

Mains or generator (when available)

200WHr daily shallow cycle (but several day emergency reserve).

An open source CDN is needed?

- A reliable transport protocol with FEC, together with scheduler GUI and carousel, capable of operating with or without a return channel.
- Many commercial examples: Kencast, Fantastic (defunct), Skystream (Tandberg) zBand, Stratacache OmniCache (based on Starburst), International Datacasting Datacast XD, Newtec's Tellitec Tellicast, Digital Fountain File Broadcast , (not to mention Akamai sort of services).
- Excellent work already done, such as SAT-RMTP, ALC, NORM, etc.
- Support NACK concentrators someday?

FEC is the enabling technology

- Michael Mitzenmacher survey paper, conclusion: “The development of new approximations to digital fountains, unencumbered by potential patent protection and accompanied by freely available reference implementations, could greatly speed adoption, and provides a theoretical and technical challenge to the community.”
- EU FP7 Digitalworld project hopes to catalyze some funding for development and validation of an IPR free Gallagher type rateless erasure correction code(s). Several recognized leaders have agreed to be involved such as Turbo Code inventor Claude Berrou of ENST and colleagues.

IPR free FEC is needed elsewhere

- Solution for concatenated WiFi/WiMax links that suffer high loss.
  - Tunnel with FEC?
  - FEC enhanced TCP?
  - RMT like transport w/TCP gateway?
- School server to student laptop streaming.

From 2001: A Space Odyssey
by Aruthr C. Clark

Newspad

“Floyd sometimes wondered if the Newspad, and the fantastic technology behind it, was the last word in man's quest for perfect communications. Here he was, far out in space, speeding away from Earth at thousands of miles an hour, yet in a few milliseconds he could see the headlines of any newspaper he pleased. (That very word "newspaper," of course, was an anachronistic hangover into the age of electronics.) The text was updated automatically on every hour; even if one read only the English versions, one could spend an entire lifetime doing nothing but absorbing the ever-changing flow of information from the news satellites.”

See:
http://www.tcjnet.com/xosat.html
Thanks!

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