INTERNET TECHNOLOGY, ECONOMICS AND POLICY

Henning Schulzrinne

http://www.cs.columbia.edu/~hgs/teaching/itep/
CLASS OVERVIEW
Big questions

• How does the Internet work, technically?
• How come your Internet bill is so high (or low)?
• What’s hard about extending the Internet to rural areas?
• Is the Internet local, national or international?
• What does it mean for the Internet to be “open” or “neutral”?
• How can we make the Internet useful for public safety, people with disabilities?
• Why do carriers pay billions of dollars for spectrum?
• What makes “cyber security” hard?
What’s on the syllabus?

• Overview of Internet technology (how does the Internet work)
• Review of basic principles of micro-economics
• How does the law work?
• A bit of communication history
• The role of communication policy and regulation
  • Telecom Act, FCC overview
• Common carriage, significant market power and other regulatory frameworks
• Protocol and architecture standardization (IETF, 3GPP, OMA, ...)
• The economics of networks
  • building networks, natural monopolies, ...
• Wireless communications
  • From AM radio to cellular
  • Spectrum: properties, allocation and co-existence
What’s on the syllabus?

- Network neutrality and the Open Internet
- Peering, transit and traffic exchange
- Names, numbers and addresses
- *Internet security challenges*
  - Basic principles of network security
  - “Cybersecurity”
  - Unwanted communication
  - Privacy and surveillance
- *Communication for all*
  - Enabling technologies for people with disabilities (relay services, accessibility, CVAA, ...)
- Internet governance
  - ICANN, ITU and other actors
What should you be able to do after taking the class?

- Elevator pitch
  - “What is spectrum and why is it hard to find” – in 2 minutes
- In-depth survey
  - “The economics of Internet adoption in rural and urban areas”
- Research
  - Know sources and approaches
    - engineering models vs. economic models vs. legal analysis
  - Appreciate need to consider
    - technical feasibility
    - economic factors
    - policy enablers and constraints
Materials

- No formal text book, but draws from
  - “The Master Switch” (T. Wu).

- Other materials:
  - Technical papers (IEEE, ACM, tech reports, …)
  - White papers
  - Industry analysis reports
  - Regulatory filings (FCC, Ofcom, BEREC, …)
  - Laws & regulations
How to benefit from this class

• Be prepared (e.g., read assigned materials)
• Expand your mental horizon beyond your discipline
• Participate in class discussion
• Pick an interesting project
  • “big data”
  • apps & software for public-good applications
  • system modeling
How not to benefit

- Catch up on Facebook
- Cat videos!
- Transcribe the class into your notebook
- Flip through the slides
- Voice only popular opinions
  - or opinions you read in the NY Times or WSJ
- Believe that the instructor is always right
  - on facts or interpretation
Mechanics

- Homework assignments
  - may allow options to accommodate different backgrounds

- Semester paper
  - start early – may need to be defined by iteration
  - outcome: research paper
  - may be review, quantitative analysis or experiment (not just software)

- Pop quizzes, occasionally

- Guest (video) lectures
  - colleagues from Washington, DC
Semester project

• Pick topic and team by 9/21
  • including responsibilities, milestones and timeline
  • create project page

• Bi-weekly progress reports for each team

• End-of-semester presentation

• Report suitable as technical report, i.e.,
  • proper citations (IEEE format, etc.)
  • useful abstract
  • standard paper conventions, including format and style
  • not just a bunch of bullet points or graphs
Semester project

- Student chosen, with guidance
  - encourage cross-disciplinary teams
  - teams of 1-3 students
- Data analysis
  - *Measuring Broadband America*
  - other data sources (FCC, ITU)
  - own data gathering
- Measurements
  - Open Internet measurements
  - 911 services: location accuracy
  - Services for people with disabilities: closed captioning; speech-to-text
  - Spectrum measurements
- Analysis
  - Network economics (e.g., spectrum usage, pricing or universal service)
Internet growth – classical view

Figure 1

Global Internet users and penetration rate (1995-2009)

A quarter of the world’s population is online

Sources: Nielsen, ITU; A.T. Kearney analysis
US Internet use

Home broadband vs. dial-up, 2000-2013

Among all American adults ages 18 and older, the % who access the internet at home via dial-up or high-speed broadband connection, over time. As of May 2013, 70% of adults have home broadband.


See also: http://pewinternet.org/Trend-Data/Home-Broadband-Adoption.aspx
But not all are happy about this…
Basic Internet money routing

Internet

consumer spending ($11.2T)

ISP

content & service aggregators

OTT (over-the-top)

Coca-Cola

Scottrade

Ford

CenturyLink™

verizon

COMCAST

at&t
Basic video money routing

consumer spending ($11.2T 2Q15)

MSO/MVPD

retransmission consent fees

reverse compensation

Cablevision

COMCAST

Cable

channels

Ford

Scottrade

Coca-Cola

CBS

Fox

NBC

abc

Time Warner Cable

consumer spending ($11.2T 2Q15)
## More industry revenues

<table>
<thead>
<tr>
<th>Company or sector</th>
<th>US domestic revenue, 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netflix (US)</td>
<td>$3.4B</td>
</tr>
<tr>
<td>Cisco (Americas)</td>
<td>$27.8B</td>
</tr>
<tr>
<td>US cable TV</td>
<td>$56B</td>
</tr>
<tr>
<td>US film</td>
<td>$31B (2013)</td>
</tr>
<tr>
<td>US music</td>
<td>$10B (2013)</td>
</tr>
<tr>
<td>US Games (software)</td>
<td>$20.5B</td>
</tr>
<tr>
<td>US Wireless telecom</td>
<td>$205B</td>
</tr>
<tr>
<td>Google (worldwide)</td>
<td>$66B (56% international)</td>
</tr>
</tbody>
</table>
Cable TV subscriptions

Number of cable TV subscriptions

Year

Millions

0 20 40 60 80 100 120
News revenue

- 2012: $38.6B for 1,400 US dailies
  - 2/3 ($25.2B) from advertising
  - ¼ ($10.4B) digital & print circulation
  - rest: events, commercial printing, e-commerce, ...

- 12 cable news channels, 3 broadcast networks news, 800 news-producing local TV stations
  - $16.4B revenue
  - total of about 2,200 TV stations
  - 3 news networks: $691M average

- Non-commercial sector: $1.9B
  - includes 1,000 local public radio stations
## 2014 U.S. Advertising

### Exhibit 9

**U.S. 2014 Advertising Model Estimates Changes**

<table>
<thead>
<tr>
<th>U.S. Advertising Market</th>
<th>2013</th>
<th>2014E</th>
<th>Y/Y</th>
<th>Prior</th>
<th>Y/Y</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Television (incl Political)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local Stations</td>
<td>22,815</td>
<td>25,548</td>
<td>12.0%</td>
<td>10.0%</td>
<td>199bps</td>
<td></td>
</tr>
<tr>
<td>Broadcast Nets (Big 4)</td>
<td>14,820</td>
<td>15,122</td>
<td>2.0%</td>
<td>5.0%</td>
<td>(300bps)</td>
<td></td>
</tr>
<tr>
<td>National Cable</td>
<td>29,532</td>
<td>31,009</td>
<td>5.0%</td>
<td>6.0%</td>
<td>(100bps)</td>
<td></td>
</tr>
<tr>
<td>Local Cable</td>
<td>4,559</td>
<td>4,901</td>
<td>7.5%</td>
<td>6.0%</td>
<td>153bps</td>
<td></td>
</tr>
<tr>
<td>Syndication (incl UPN, WB, CW, MNTV)</td>
<td>4,537</td>
<td>4,537</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0bps</td>
<td></td>
</tr>
<tr>
<td><strong>Total Television</strong></td>
<td>76,263</td>
<td>81,117</td>
<td>6.4%</td>
<td>6.6%</td>
<td>(28bps)</td>
<td></td>
</tr>
<tr>
<td>Newspapers (ex. classified)</td>
<td>13,677</td>
<td>12,584</td>
<td>-8.0%</td>
<td>-8.0%</td>
<td>0bps</td>
<td></td>
</tr>
<tr>
<td>Radio</td>
<td>16,648</td>
<td>16,643</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0bps</td>
<td></td>
</tr>
<tr>
<td>Consumer Magazines</td>
<td>13,051</td>
<td>12,789</td>
<td>-2.0%</td>
<td>-2.0%</td>
<td>0bps</td>
<td></td>
</tr>
<tr>
<td>Internet (Display &amp; Search)</td>
<td>43,884</td>
<td>51,344</td>
<td>17.0%</td>
<td>15.0%</td>
<td>200bps</td>
<td></td>
</tr>
<tr>
<td>Outdoor</td>
<td>6,976</td>
<td>6,976</td>
<td>0.0%</td>
<td>3.0%</td>
<td>(300bps)</td>
<td></td>
</tr>
<tr>
<td><strong>Total Advertising</strong></td>
<td>170,499</td>
<td>181,453</td>
<td>6.4%</td>
<td>6.2%</td>
<td>27bps</td>
<td></td>
</tr>
<tr>
<td><strong>Media ex Print</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Traditional Media (ex Internet)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Company reports, MoffettNathanson estimates and analysis
Digital advertising revenue

Quarterly revenue growth trends Q1 1996 – Q1 2015 ($ billions)

Source: IAB/PwC 2015
Who is advertising?

Internet ad revenues by major industry category
$42.8 B in 2013 vs. $49.5 B in 2014

- Retail: 21% (FY 2014) vs. 21% (FY 2013)
- Financial Services: 13% (FY 2014) vs. 13% (FY 2013)
- Auto: 12% (FY 2014) vs. 12% (FY 2013)
- Telecom: 9% (FY 2014) vs. 9% (FY 2013)
- Leisure Travel: 8% (FY 2014) vs. 9% (FY 2013)
- Consumer Packaged Goods: 7% (FY 2014) vs. 6% (FY 2013)
- Consumer Electronics & Computers: 6% (FY 2014) vs. 7% (FY 2013)
- Media: 5% (FY 2014) vs. 5% (FY 2013)
- Pharma & Healthcare: 5% (FY 2014) vs. 5% (FY 2013)
- Entertainment: 4% (FY 2014) vs. 4% (FY 2013)

† Amounts do not total to 100% as minor categories are not displayed.
Source: IAB Internet Advertising Revenue Report, FY 2014

April 2015
What kind of advertising?

- Display ads
  - brand awareness, mostly
  - fixed cost or bidding for pages
  - pop-ups, inline, interstitial (before & after)
- Search ads
  - bidding for key words
- Location-based (push) advertising
- Email-based
- Sponsored content
- Video ads
  - Pre-roll & insert
- Classifieds (e.g., Craigslist)
Advertising reach

- Classical
  - TV, radio: rating points – 1% of TV households (116.3 M in 2014)
    - particular A18-49 (adults 18 to 49)
    - Live, Live+SD, Live+7
  - Newspaper: circulation
- Digital
  - CPM: thousand impressions
    - $2.80 display ads; $5 email; $3 video
  - CPC: thousand clicks
    - → CTR: click-through rate
      (relevance for mobile?)
  - Google AdSense: 68% to publisher, 32% to Google

TV CPM

In looking at traditional TV video CPMs, Media Dynamics says broadcast network prime time is the highest -- at $19.00. Late-night broadcast programming is at $17.50; syndicated prime-access programming is at $17.00; and cable prime-time programming at $9.85.

Early-fringe syndicated programming averages $9.25; broadcast early evening news is at $9.00; and cable programming early fringe comes in at $7.55. Network daytime is at $6.50; with syndicated daytime programming at $5.50; and cable daytime programming at $3.30.

Radio CPM: ~$20

If the majority of a radio station's audience falls outside the 25-54 age range, you can expect the CPM rate to be on the lower side. Talk radio and country music formats tend to attract an older audience in general. However, if a station has a predominantly male audience between 18-35, you should expect rates to be higher. If a station attracts a wealthy audience, for example a jazz or classical station, you should also expect to pay higher CPM rate.
# How much can you make on web ads?

<table>
<thead>
<tr>
<th>Rank</th>
<th>Website</th>
<th>Ad Format</th>
<th>Impressions</th>
<th>Price/1K Impressions</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PelFusion</td>
<td>BSA Premium Ad Zone 300x250 Top Right</td>
<td>184K</td>
<td>$0.75</td>
<td><a href="https://buysellads.com/buy/leaderboard/id/17/soldout/1/ch/47">Waiting List</a></td>
</tr>
<tr>
<td>2</td>
<td>Literally Unbeliev</td>
<td>Middle Left Sidescraper 160x600 Middle Left</td>
<td>301K</td>
<td>$1.00</td>
<td><a href="https://buysellads.com/buy/leaderboard/id/17/soldout/1/ch/47">Buy Now</a></td>
</tr>
<tr>
<td>3</td>
<td>Leather Celebritie</td>
<td>Leaderboard Premium (header) 728x90 Top Center</td>
<td>1.05M</td>
<td>$0.40</td>
<td><a href="https://buysellads.com/buy/leaderboard/id/17/soldout/1/ch/47">Buy Now</a></td>
</tr>
<tr>
<td>4</td>
<td>Fun Tweets</td>
<td>Site-wide 468x60 468x60 Bottom Center</td>
<td>193K</td>
<td>$0.30</td>
<td><a href="https://buysellads.com/buy/leaderboard/id/17/soldout/1/ch/47">Buy Now</a></td>
</tr>
<tr>
<td>5</td>
<td>Lifehack</td>
<td>Premium ATF Top Leaderboard 728x90 Top Center</td>
<td>14.61M</td>
<td>$4.50</td>
<td><a href="https://buysellads.com/buy/leaderboard/id/17/soldout/1/ch/47">Buy Now</a></td>
</tr>
<tr>
<td>6</td>
<td>Shadowbinders.com</td>
<td>Underneath Comic - Leaderbo 728x90 Top Center</td>
<td>48K</td>
<td>$1.00</td>
<td><a href="https://buysellads.com/buy/leaderboard/id/17/soldout/1/ch/47">Buy Now</a></td>
</tr>
<tr>
<td>7</td>
<td>Illusion Magazine</td>
<td>Premium Leaderboard (In-Pos) 728x90 Top Left</td>
<td>322K</td>
<td>$3.50</td>
<td><a href="https://buysellads.com/buy/leaderboard/id/17/soldout/1/ch/47">Buy Now</a></td>
</tr>
<tr>
<td>8</td>
<td>Leather Celebritie</td>
<td>Rectangle Premium (sidebar) 300x250 Top Right</td>
<td>571K</td>
<td>$1.00</td>
<td><a href="https://buysellads.com/buy/leaderboard/id/17/soldout/1/ch/47">Buy Now</a></td>
</tr>
<tr>
<td>9</td>
<td>Shadowbinders.com</td>
<td>'Always There' Tower 160x600 Top Right</td>
<td>58K</td>
<td>$1.00</td>
<td><a href="https://buysellads.com/buy/leaderboard/id/17/soldout/1/ch/47">Waiting List</a></td>
</tr>
<tr>
<td>10</td>
<td>Heckler Spray</td>
<td>Top of Right Sidebar - ATF 300x250 Top Right</td>
<td>10,000,000</td>
<td>$1.35</td>
<td><a href="https://buysellads.com/buy/leaderboard/id/17/soldout/1/ch/47">Buy Now</a></td>
</tr>
</tbody>
</table>
Web and mobile advertising

• Not just CPM – multiple ads per page
  • “$48/1000 visits”
  • $0.25-$3 for generic sites
  • $1-$10 for content rich sites
  • $10 for product-related sites

• Ad tracking
  • cross-site cookies – embedded frames or images
    • or track by IP address, browser characteristics, etc.
  • effectiveness?

• Impact of ad blocking?
  • IOS9
Example trackers (New York Times)

Privacy Badger detected 16 trackers on this page. These sliders let you control how Privacy Badger handles each tracker.

- static.chartbeat.com
- st.dynamicyield.com
- static.dynamicyield.com
- www.facebook.com
- www.google-analytics.com
- partner.googleadservices.com
Tracking users and households

- Cookies (“same origin policy”)
- IP address
- Browser characteristics
  - e.g., user agent, links visited
- “Super cookies”
- ISP-based tracking

---

Receive our U-verse with AT&T GigaPower Premier Offer by choosing AT&T Internet Preferences. When you select AT&T Internet Preferences, we can offer you our best pricing on GigaPower because you let us use your individual Web browsing information, like the search terms you enter and the web pages you visit, to tailor ads and offers to your interests.

You won’t necessarily receive more ads when you are online, but those you do see may be more suited to your interests. For example:

- If you search for concert tickets, you may receive offers and ads related to restaurants near the concert venue.
- After you browse hotels in Miami, you may be offered discounts for rental cars there.
- If you are exploring a new home appliance at one retailer, you may be presented with similar appliance options from other retailers.

You might receive these offers or ads online, via email or through direct mail. You have our pledge that AT&T is committed to protecting your privacy. We will not sell your personal information to anyone, for any reason. Period.
Browser strings

What’s My User Agent?

Your User Agent String is: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_10_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/45.0.2454.93 Safari/537.36

Your IP Address is: 128.59.18.120

Client Information:

- JavaScript Enabled: Yes
- Cookies Enabled: Yes
- Device Pixel Ratio: 1
- Screen Resolution: 1920 px X 1200 px
- Browser Window: 1271 px X 927 px
- Local Time: 5:04 pm
- Time Zone: -4 hours
What kind of advertising?

Distributing Mobile across formats demonstrates its importance to Search and Display

Formats –2014
(Mobile separated)

- Search: 38%
- Display: 27%
- Other: 10%
- Mobile: 25%

Source: IAB Internet Advertising Revenue Report, FY 2014

Formats –2014
(Mobile included)

- Search: 50%
- Display: 40%
- Other: 10%

Real-time brokered: $2B
US dominates marketing

### Top ten ad markets

**US$ million, current prices.** Currency conversion at 2012 average rates.

<table>
<thead>
<tr>
<th>2012</th>
<th>Adspend</th>
<th>2015</th>
<th>Adspend</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>USA</td>
<td>161,241</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Japan</td>
<td>51,742</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>China</td>
<td>37,202</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Germany</td>
<td>23,433</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>UK</td>
<td>19,375</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>Brazil</td>
<td>15,298</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>Australia</td>
<td>12,813</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>France</td>
<td>12,490</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>Canada</td>
<td>11,454</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>South Korea</td>
<td>10,738</td>
<td>10</td>
</tr>
</tbody>
</table>

*Source: ZenithOptimedia*
Global ad spending by medium

Share of global adspend by medium (%)

2012

- Television: 40.0%
- Internet: 18.3%
- Newspapers: 18.7%
- Magazines: 7.0%
- Radio: 6.9%
- Outdoor: 8.5%
- Cinema: 0.6%

2015

- Television: 39.5%
- Internet: 24.6%
- Newspapers: 14.9%
- Magazines: 10.8%
- Radio: 6.8%
- Outdoor: 7.0%
- Cinema: 0.6%

Source: ZenithOptimedia
Converging communities

since 1900: separate networks, companies, professions

- **Data**: 1960s
  - Generality
  - Data integrity
  - Access control

- **Broadcast** (radio, TV):
  - 1896
  - 1915
  - Low cost
  - Scalability
  - Copyright protection (DRM)

- **Voice** (telephone):
  - 1876
  - Human to human
  - IM
  - Ease of use
  - Universality
  - Reliability
  - Privacy

- Internet

- Machine to machine
- Machine to human
- Human to human
Lifecycle of technologies

traditional technology propagation:

- military: opex/capex doesn’t matter; expert support
- corporate: capex/opex sensitive, but amortized; expert support
- consumer: capex sensitive; amateur

Can it be done?  Can I afford it?  Can my mother use it?
Internet and networks timeline

- **1960**: Theory
- **1970**: University prototypes
- **1980**: Production use in research
- **1990**: Commercial early residential
- **2000**: Broadband home
- **2010**: Internet everywhere

Port speeds:
- **1960-1970**: 100 kb/s
- **1980-1990**: 1 Mb/s
- **1990-2000**: 10 Mb/s
- **2000-2010**: 100 Mb/s

Internet protocols:
- **Email**
- **FTP**
- **DNS**
- **RIP**
- **UDP**
- **TCP**
- **SMTP**
- **SNMP**
- **finger**
- **ATM**
- **BGP, OSPF**
- **Mbone**
- **IPsec**
- **HTTP**
- **HTML**
- **RTP**
- **XML**
- **OWL**
- **SIP**
- **Jabber**
- **p2p**
- **ad-hoc**
- **sensor**

Queuing and congestion control:
- **DQDB, ATM**
- **QoS**
- **VoD**

Protocols and standards:
- **XML**
- **OWL**
- **SIP**
- **Jabber**
- **p2p**
- **ad-hoc**
- **sensor**

Note: The timeline and content are simplified for educational purposes. Actual dates and developments may vary.
## What has changed?

<table>
<thead>
<tr>
<th>1980s/1990s</th>
<th>2000s+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapid technology evolution in network core</td>
<td>Relatively stable core technology</td>
</tr>
<tr>
<td>Internet exceptionalism (no distance! no borders!)</td>
<td>National laws &amp; customs</td>
</tr>
<tr>
<td>Internet utopianism</td>
<td>“Big Switch”, harms &amp; limitations</td>
</tr>
<tr>
<td>Performance!</td>
<td>Reliability?</td>
</tr>
<tr>
<td>Cost-insensitive (and “free” phone access)</td>
<td>Deployment cost barriers</td>
</tr>
<tr>
<td>Separated from commercial media (newspaper, magazines, radio, TV)</td>
<td>Affects all media</td>
</tr>
<tr>
<td>Self-revealed data (email, BBS)</td>
<td>Intimate data (information access, behavioral)</td>
</tr>
<tr>
<td>Little economic impact</td>
<td>One of the largest US exports</td>
</tr>
</tbody>
</table>
## What’s different?

<table>
<thead>
<tr>
<th>What</th>
<th>Utilities (gas, water, electricity)</th>
<th>Internet</th>
<th>Consumer electronics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geographic scope</td>
<td>regional</td>
<td>local, national, international</td>
<td>mostly international</td>
</tr>
<tr>
<td>Economics</td>
<td>enabler</td>
<td>entry, competition, enabler</td>
<td>Trade, patents</td>
</tr>
<tr>
<td>Impact on culture</td>
<td>minimal</td>
<td>foundational</td>
<td>rarely (Walkman, iPhone)</td>
</tr>
<tr>
<td>Impact on domestic politics</td>
<td>in LDCs</td>
<td>jobs, education, health, transportation, copyright, income inequality</td>
<td>health &amp; education (smartphones)</td>
</tr>
<tr>
<td>Impact on international politics</td>
<td>water rights?</td>
<td>trade, espionage, propaganda, cyberattacks, copyright, ...</td>
<td>trade</td>
</tr>
</tbody>
</table>

9/28/15

ITEP 39