The Economics of E-commerce and Technology

Network Effects
Network Effects

- Network
  - Set of interconnected nodes
  - Real network (faxes) and virtual networks (Word users)

- Network effect (or network externality)
  - A’s value depends on number of other users (and identity)
  - Positive network effects: email, videoconferencing
  - Negative network effects: congestion

- Scale economies
  - Network effects = demand-side scale economies
  - Different from supply-side scale economies (i.e. falling MC)

- Consider the following examples:
  - Electric cars, Gchat, Gmail.
Direct vs. Indirect

- **Direct network effects**
  - Users care inherently about other users (e.g. Gchat, faxes)

- **Indirect network effects**
  - Users care about complements (e.g. Apps, games, fuel pumps)
  - Think of as one-sided network good if firm passive in market for complements (e.g. electric cars and fueling stations).
  - Think of as platform market if firm controls market for complements (e.g. Xbox prices for games and consoles).
Growth of a Network

Facebook and Myspace: Monthly U.S. Unique Visitor (000) Trend
Source: comScore Media Metrix, U.S., Aug-05 - May-11

- Launch
- Takeoff
- Saturation
Demand Side
Metcalf’s Law
Strength of Network Effects

- Metcalfe’s law: \( V(N) = k(N-1) \)
  - Care about total number of nodes in network.
- Quicker growth at start
  - On Facebook, I care if my friends are linked (becomes standard)
  - Want all my friends on Facebook so I can send out invitations
  - Fixed cost of entry for complements (e.g. electric cars)
- Satiation
  - At Match.com don’t care about 1000\(^{th}\) person as much as 10\(^{th}\)
  - People joining first may be more valuable to the network
Agent’s Values

- An agent’s value rises as the network size grows
How does value vary across networks?

- How does $V(N)$ vary across networks?
  - Stand alone value minus homing cost (eHarmony vs Match)
  - Importance of network effects (Word vs Powerpoint)
- People care about identity of those in the network
  - On Facebook, I mainly care about my friends
  - Density of network matters (Friendster in SF, Facebook at Harvard)
  - On Twitter, I mainly care about celebrities
  - On Match, I care about people in target market
  - On Bit Torrent, I care about variety of movies
  - With credit card, I care about which stores accept card
- May be a member of different networks (multi-home)
  - Like other products, networks are differentiated (e.g. Xbox vs Wii).
Model of Network Effects
Demand Curves

- Demand curves corresponding to three network sizes
Fulfilled Expectations Demand Curve

- Values where expected demand equals realized demand
  - Intercept negative – positive homing cost, e.g. training, capital.
Perfect Competition (e.g. email, faxes)

- Marginal cost pricing yields three equilibria: $N_0$, $N_1$, $N_2$. 
Role of Expectations

- Expectations are crucial
  - Homing cost (i.e. product cost, training costs) mean don’t want to buy if N low.
  - Care about current base and expected future base.
  - Product will succeed if it is expected to succeed!

- Penguin problem
  - Consumer faces uncertainty about technology and future N.
  - No-one wants to adopt first.
Role of Expectations

- Equilibrium $N_1$ is unstable (called “tipping point”)
  - If start with $N > N_1$, get virtuous cycle: $N \rightarrow N_2$.

- Exercise: What happens if start with $N < N_1$?
What to do about Expectations?

- Manage expectations directly
  - Product announcements (vaporware)

- Enable users to internalize externality
  - LinkedIn asks you to invite friends

- Give introductory discounts
  - Need network “sponsor” to have market power to overcome free-riding (unless all industry commits)
  - Risk of adverse selection (e.g. Xbox as DVD player)

- Have people sign contracts
  - “I’ll adopt if at least N people do”

- Start with small networks (e.g. eHarmony)
  - Local vs. global network effects
Managing Expectations
Managing Expectations
Monopoly Pricing (e.g. Word, eBay)

- At optimal quantity $N^*$, $MR = MC$. Yields price $P^*$.
  - But if charge price $P^*$, there are three equilibria: $N_0, N_1, N^*$
Monopoly: Unique Implementation

- By charging $P(N)$ the firm can pick $N^*$ as only equilibrium
  - Analogous to introductory discounts for early adopters.
Monopoly Pricing: Formal Analysis

- Let $n$ be market size, $n^e$ be expected market size
  - Demand curve is $p(n;n^e)$.
  - Fulfilled expectations demand is $p(n;n)$, where $n=n^e$.
- Cost $c(n)$
- Firm chooses $n$ to maximize $\pi = np(n;n)-c(n)$.
  - Ignoring problem of multiple equilibria.
- The first order condition is
  
  $$p(n;n) + n \frac{\partial p(n;n)}{\partial n} + n \frac{\partial p(n;n)}{\partial n^e} = \frac{\partial c(n)}{\partial n}$$

  - First and second terms – standard marginal revenue.
  - Third term – network effect, i.e. how increasing ‘$n$’ increases value of marginal user. Like an increase in marginal revenue.
Two Technologies

- We have so far considered one technology
  - Two stable equilibria: N0 and N2
- If two technologies, A and B, there are three equilibria
  - A wins, B wins, or neither wins.
- Multiple technologies might make “neither” more likely
  - Customers don’t know who will win, and so wait.
  - Examples: AM stereo radio, Satellite radio, Cell phone standards
- Expectations matter
  - Not just what you think will win…
  - …but what you think others think will win
Higher order beliefs...

Kitten
Slow Loris
Baby Polar Bear

Vote for the animal you think is the cutest.

- 23%
- 50%
- 27%

Vote for the animal you think is most likely to be voted the cutest by other participants.

- 10%
- 15%
- 76%

Note: Due to rounding, totals may not add up to 100 percent
Strategy
Mobilizing in Practice: Facebook

- Started at Harvard in February 2004
  - Built on existing social networks (75% of Harvard within month)
  - Easy to find friends (using course register)
  - Can invite friends (internalizing externalities)
  - Used influential people (Phoenix club)

- Expansion
  - Expanded through Universities (use existing social structure)
  - Aura of exclusivity (only expand when success guaranteed)
  - Surrounded holdout University to conquer (network effect)

- Ultimately successful because
  - Innovative (mapped network, news feed, photos, Inbox, applications)
  - Privacy controls (people share more information)
  - Reliable
Launching New Technologies

- Network effects act like collective switching costs
  - Small switching costs are magnified.

- Entrant comes into industry (e.g. Gchat)
  - Need people to switch in coordinated way.
  - Problem where there are positive homing costs.

- Example: QWERTY vs. Dvorak
  - Dvorak is better layout – typing is quicker.
  - Costly to train on new system.
  - Typing interface has network effects.

- Sometimes new format work; sometimes not
  - Examples: CDs, DAT, DCC, Minidisc.
Compatibility Choices

- Backwards compatible – new technology reads old input
  - Word 07 reads .doc files
  - PS3 plays PS2 games, but PS4 cannot play PS3 games.

- Forwards compatible – old technology reads new input
  - Word 2003 converter for .docx files
  - But cannot save .docx files.

- Tradeoffs
  - Compatibility may cause loss of performance
  - Compatibility increases network effects
  - Force people to upgrade because of network effects
  - “Re-close” network by undoing competitors imitation.
Closed Systems: Standards Wars

- Winner takes all competition?
  - Electricity?
  - VCRs?
  - Consoles?
  - Instant Messaging?

- What are determinants?
  - Is multi-homing possible?
  - Strength of network effects
  - Demand for variety across networks.

- If winner takes all, firms compete for prize
  - Willing to sustain losses in the short-term
  - War of attrition.
War of Attrition

- Two firms: A and B
  - Make \( \pi - c \) per period if monopolist.
  - Make \(-c\) per period if duopolist (Bertrand competition).
  - Each period choose whether to stay or quit industry.

- Asymmetric equilibrium
  - A always stays and makes \( (\pi-c)/(1-\delta) \); B immediately quits.

- Symmetric equilibrium (rent dissipation)
  - Both quit with probability \( p \) per period.
  - Both indifferent between staying and quitting:
    
    \[
    p \left( \frac{\pi - c}{1 - \delta} \right) + (1 - p)(-c) = 0 \quad \Rightarrow \quad p = \frac{(1 - \delta)c}{\pi - \delta c}
    \]

  - Hence \( p \) rises as \( \pi \) falls, \( c \) rises or \( \delta \) falls.
How to Avoid a War of Attrition?

- **Pre-emption**
  - First-mover advantage
  - Penetration pricing
  - Win over influential customers (early adopters)

- **Expectations management**
  - Vaporware – MS operating system, Apple devices
  - Make claims about network size, e.g. “world’s largest”

- **Vibrant market for complements**
  - Develop own complements (e.g. VHS vs. Betamax)
  - Buy exclusive right to complements (e.g. MS and Halo)
The other guys just don’t stack up.
Example: Penetration Pricing

- Suppose $N_1$ early adopters and $N_2$ late adopters
  - All consumers have value $v(N)$ from network size $N$
  - Ignore coordination problem among users
- Stage 2: Firm $W$ has $N_1$ customers, $L$ has none.
  - Equilibrium prices: $p_W = v(N_1 + N_2) - v(N_2)$ and $p_L = 0$.
  - Profits: $\pi_W = N_2 [v(N_1 + N_2) - v(N_2)]$, $\pi_L = 0$.
- Stage 1: Neither firm has any customers.
  - How much is firm willing to bid to win customers?
  - E.g. subsidize Xbox, or development of games.
  - Subsidize early adopters if $\pi = p_1 N_1 + \pi_W \geq 0$. This yields:
    \[
p_1 \geq -\frac{N_1}{N_2} [v(N_1 + N_2) - v(N_2)]
    \]
Open vs. Closed

- **Closed – system proprietary**
  - Examples: iPhone, Betamax, IM, Mac, Windows
  - Competing for market

- **Open – interface/specifications open to others**
  - Examples: Android, VHS, email, PC, UNIX
  - Competing within market
  - Set by private firm (IBM & VGA) or committee (ITU & telecoms)

- **Degrees of openness**
  - Apple: Only get iOS on Apple phones. Control whole ecosystem.
  - Microsoft: Windows mobile licensed to any handset maker.
  - Android: Completely open. Anyone can use for free.

- **Partial compatibility**
  - MS and Netscape cooperated on secure transactions.
Why use Closed Standard?

- **Coordination**
  - Steve Jobs would phrase as integrated vs. fragmented
  - Vertical integration (e.g. chips, hardware, software, app store) allows firm to control entire user experience.

- **Dominance**
  - If market tips in favor, then are completely dominant.

- **But competitors will try to open up standard**
  - Two-sided: Need permission of both parties.
  - One-sided: One sided can use adapter (e.g. WP open .doc files)

- **As will suppliers/buyers**
  - Disney negotiated to allow customers to buy movie on Google store and play on Apple.
Why use Open Standard?

- Is Open system crazy?
  - Potential for cut-throat competition after takes off (e.g. IBM PCs)
  - Give IP away – make entry easier; lose competitive advantage.

- Advantages of Open
  - Increase network size and probability of takeoff (e.g. IBM PCs)
  - Avoid market confusion (AM Stereo, Cell phone standards)
  - Customers avoid lock-in, which again helps takeoff
  - Harness creativity of other firms

- Making money from Open
  - Licensing fees (e.g. pay $15 to make DVD player)
  - Sell complements such as service (e.g. MySQL and Sun)
  - Sell enhancements (e.g. pdf and Adobe)

- Prefer open if weak (e.g. Netscape, T-Mobile)
Standard Setting

- Standards set by committees:
  - Examples: Safety standards (UL) or Telecoms (ITU)
  - Government (NIST) or Industry (IEEE)

- Establishing a standard
  - Pools patents and overcomes coordination problems
  - Forces firms in pool to charge “fair” prices
  - Commitment to be open

- But
  - Process lengthy
  - Process may fail (e.g. DVD “read” agreed before DVD “write”)
  - Incentive to stay out of patent pool
  - Give up right to charge license fees

- Exercise: Name a product where a standard would be useful.
Example: The DVD War

- **MMCD - Sony & Phillips**
  - One sided
  - Dual layer
  - 3.7GB
  - 135 min video
  - Easy manufacture
  - Less expensive

- **SDD - Toshiba, Matsushita**
  - Two sided
  - Single layer
  - 5 GB
  - 270 min video
  - 6 channel sound

**Outcome**
- Technical Working Group of Apple, Microsoft, Sun, Dell,…
- TWG boycotted both standards until both camps agreed
- Result most similar to SDD, but dual layered
- 4000 patents in total, 20% Matsushita, 20% Pioneer, 20% Sony,…