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 1000th person as much as 10th
  - People joining first may be more valuable to the network

- How does $V(N)$ vary across networks?
  - Importance of connection between users (e.g. Word vs. LaTeX)
  - Density of network (e.g. Friendster in SF, Facebook at Harvard)
Agent’s Values

- An agent’s value rises as the network size grows
Demand is a little more complex

- People care about identity of those in the market
  - I only care if my friends are on Facebook
- Demand for variety within network
  - Homebuying (MLS listings) vs. mortgage quotes (lending tree)
  - Examples: Mobility (credit cards), Novelty (DVDs)
- Demand for variety across networks
  - Standardization leads to loss of variety.
  - Example: Xbox vs. Wii
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: N0, N1, N2.
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
  - Encourage children to buy grandmother webcam.
- 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
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.
How to Launch: 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)
  - Surrounded holdout University to conquer (network effect)

- Ultimately successful because
  - Innovative (news feed, photos, Inbox, applications)
  - Privacy controls (people share more information)
  - Reliable
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
- This assumes winner-take-all market. Networks can coexist
  - Networks differentiated
  - Multi-homing possible
  - Network effects weak
Strategy
Collective Switching Costs

- 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

- **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 vs. Gchat)
  - Is multi-homing possible?
  - Strength of network effects
  - Demand for variety across networks.

- Firms fight over the large 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:
    \[
    p \left( \frac{\pi - c}{1 - \delta} \right) + (1 - p)(-c) = 0 \implies p = \frac{(1 - \delta)c}{\pi - \delta c}
    \]
  - 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)
It's not even close. The massive Sega Genesis' library is an insane lineup of more than 190 hits. Compared to ..., well, you get the picture. But we're not just talking about games. Genesis is going off with unreal new games like Sonic the Hedgehog, Spider-Man, Bionik, and Panzer Dragoon. And for the best collection of arcade games, action/adventure, role-playing, sports, you name it, check out the Genesis Library. Nothing else stacks up.

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 customer has any customers.
  - Both firms lower prices until winner’s profit = 0
  - That is, $\pi = p_1 N_1 + \pi_W = 0$. This yields:
  
  $$p_1 = -\frac{N_1}{N_2} [v(N_1 + N_2) - v(N_2)]$$
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
  - Can be set by private firm (e.g. IBM and VGA) or by standard setting committee (e.g. ITU and telecoms)
  - Competing within market
- Compatibility decision may be one-sided or two-sided
  - Two-sided: Need permission of both parties.
  - One-sided: One sided can use adapter (e.g. WP open .doc files)
- Partial compatibility
  - MS and Netscape cooperated on secure transactions.
Why use Open?

- 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
  - 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,…