# The Economics of E-commerce and Technology

Network Effects

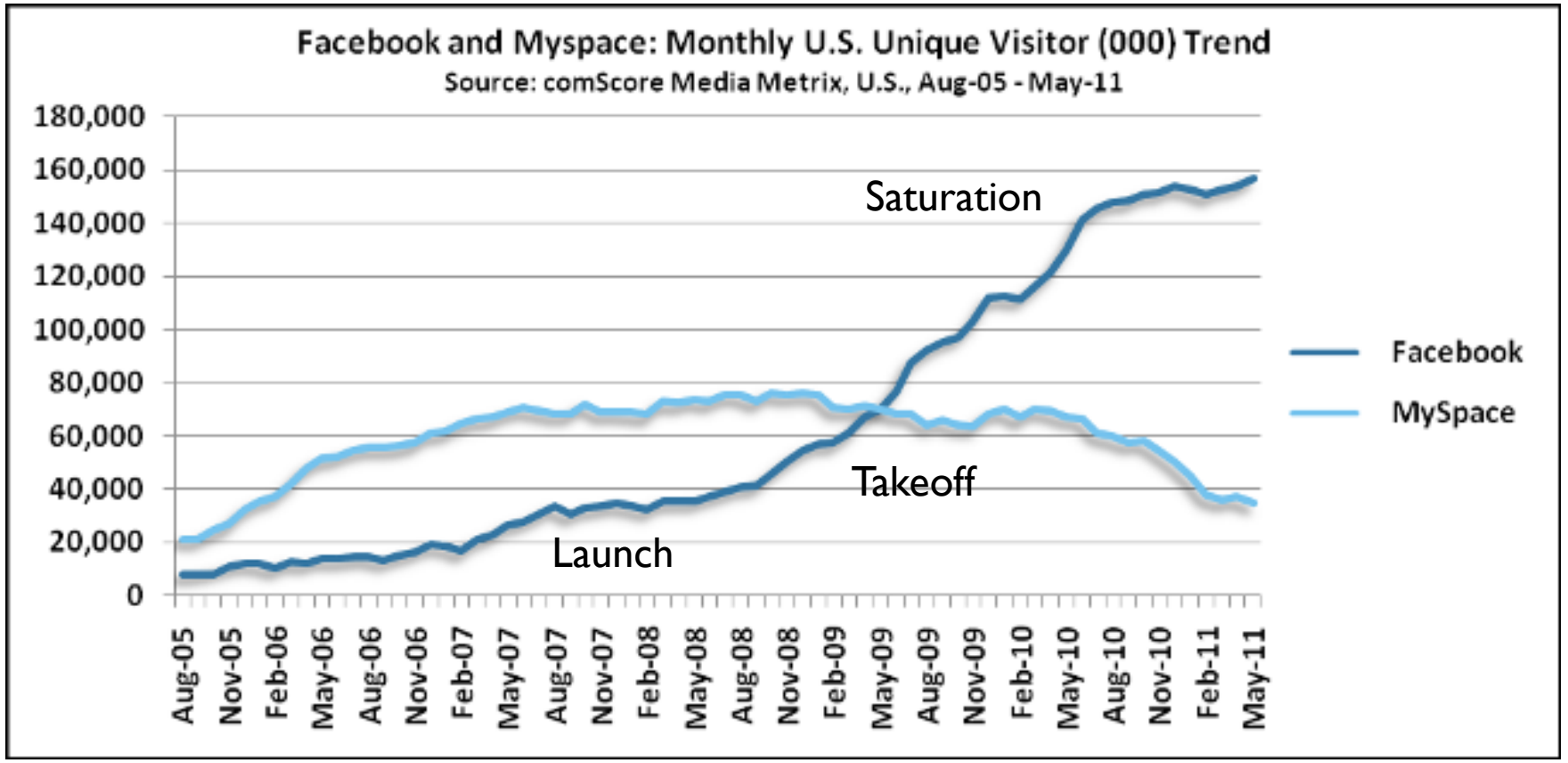
# Network Effects

- 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

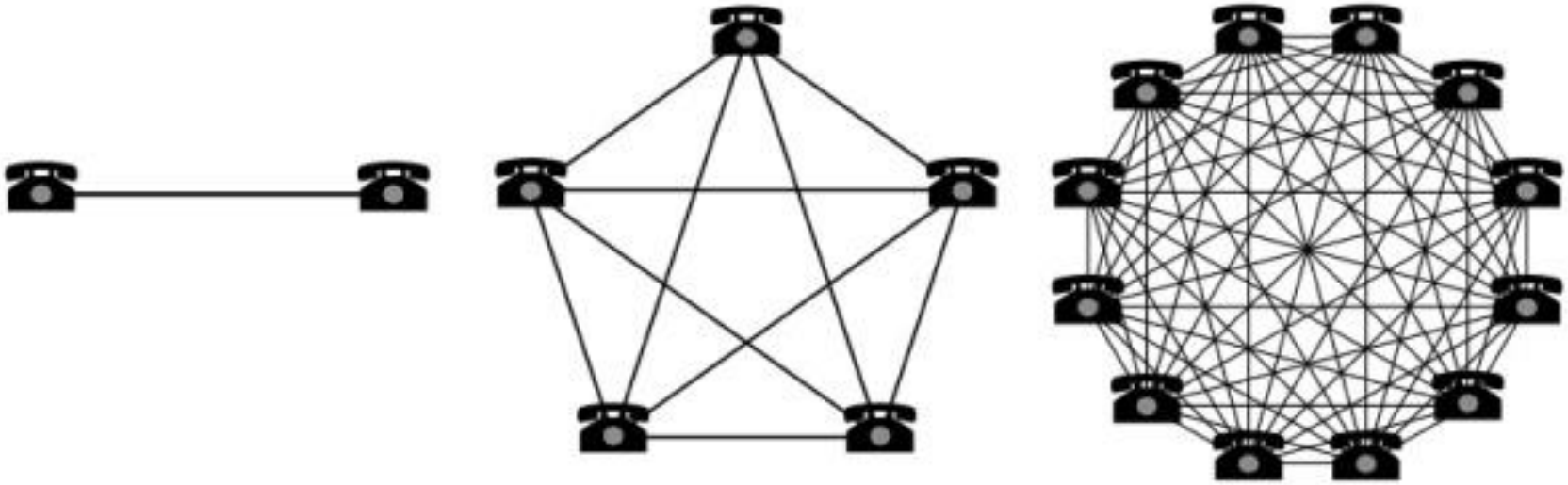
- Direct network effects
  - Users care inherently about other users (e.g. Gchat, faxes)
- Indirect network effects
  - Users care about complements (e.g. Apps, games, fuel pumps)
  - Think of as one-sided network good if firm passive in market for complements (e.g. electric cars and fueling stations).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

# Growth of a Network



# Demand Side

# Metcalfe's Law

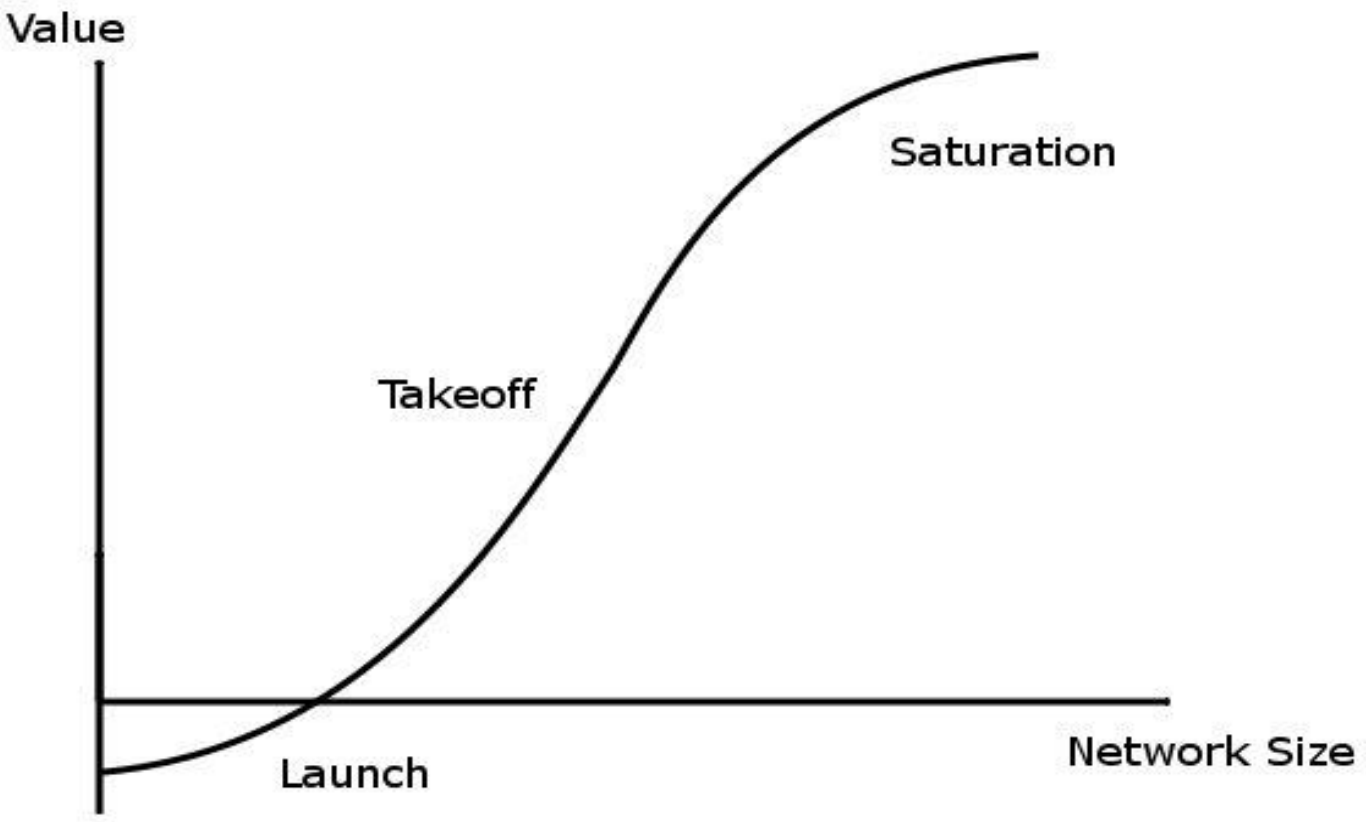


# Strength of Network Effects

- 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



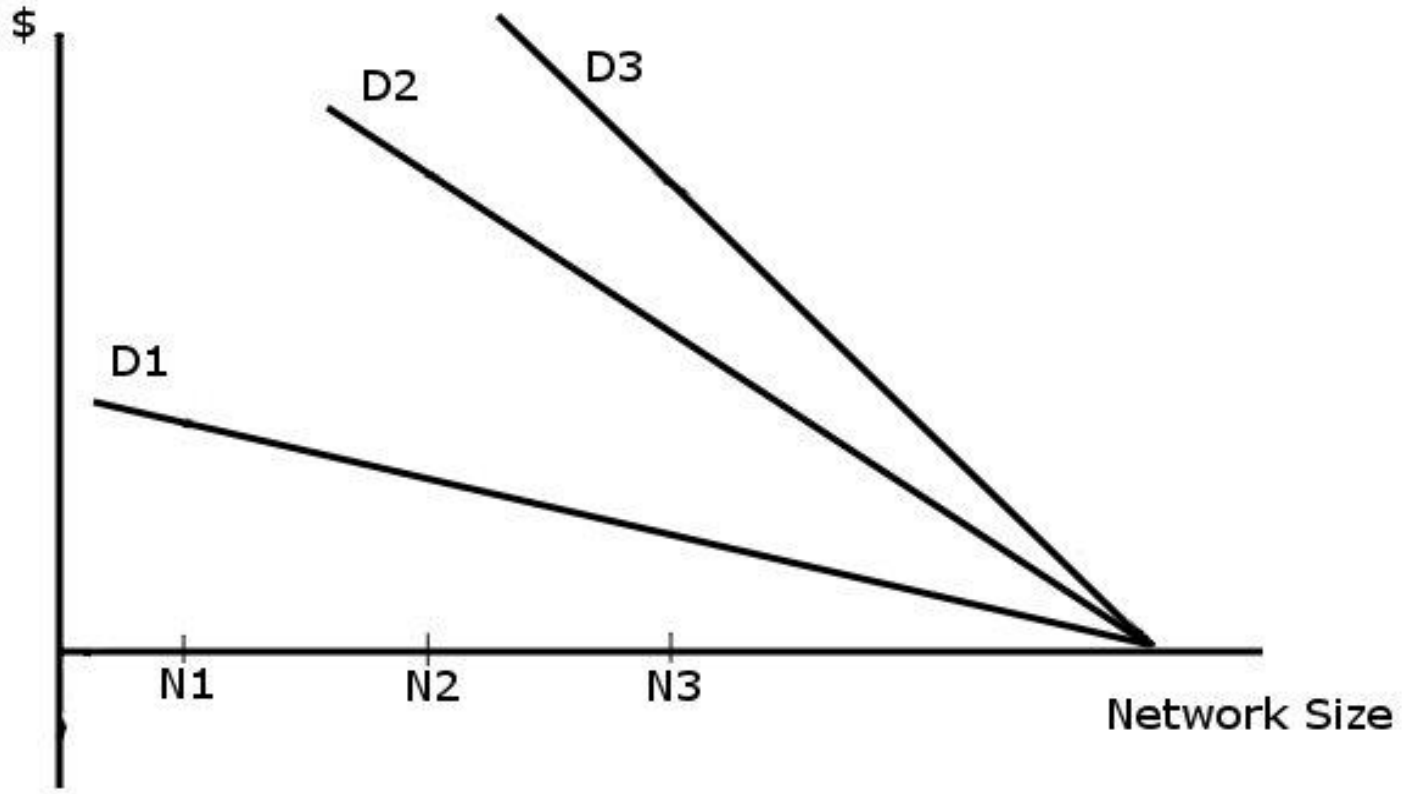
# How does value vary across networks?

- 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

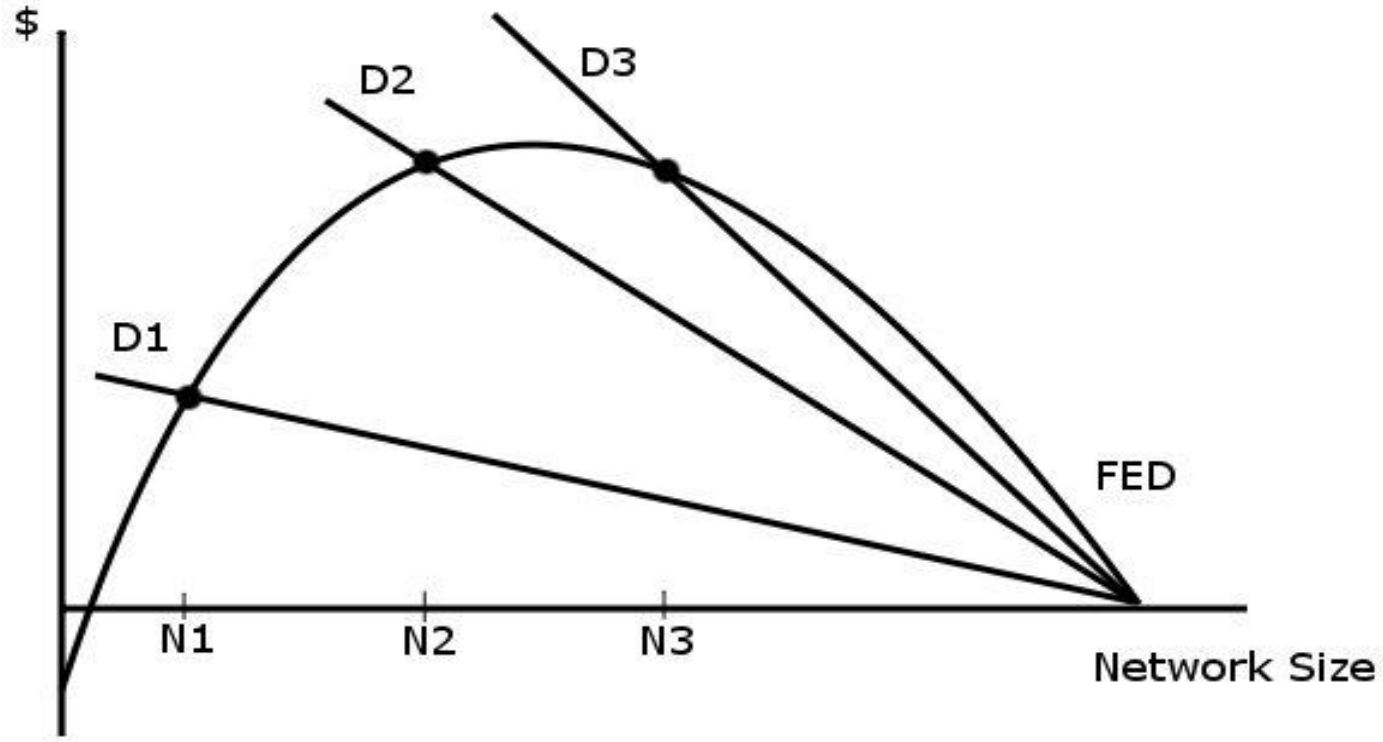
# Demand Curves

- Demand curves corresponding to three network sizes



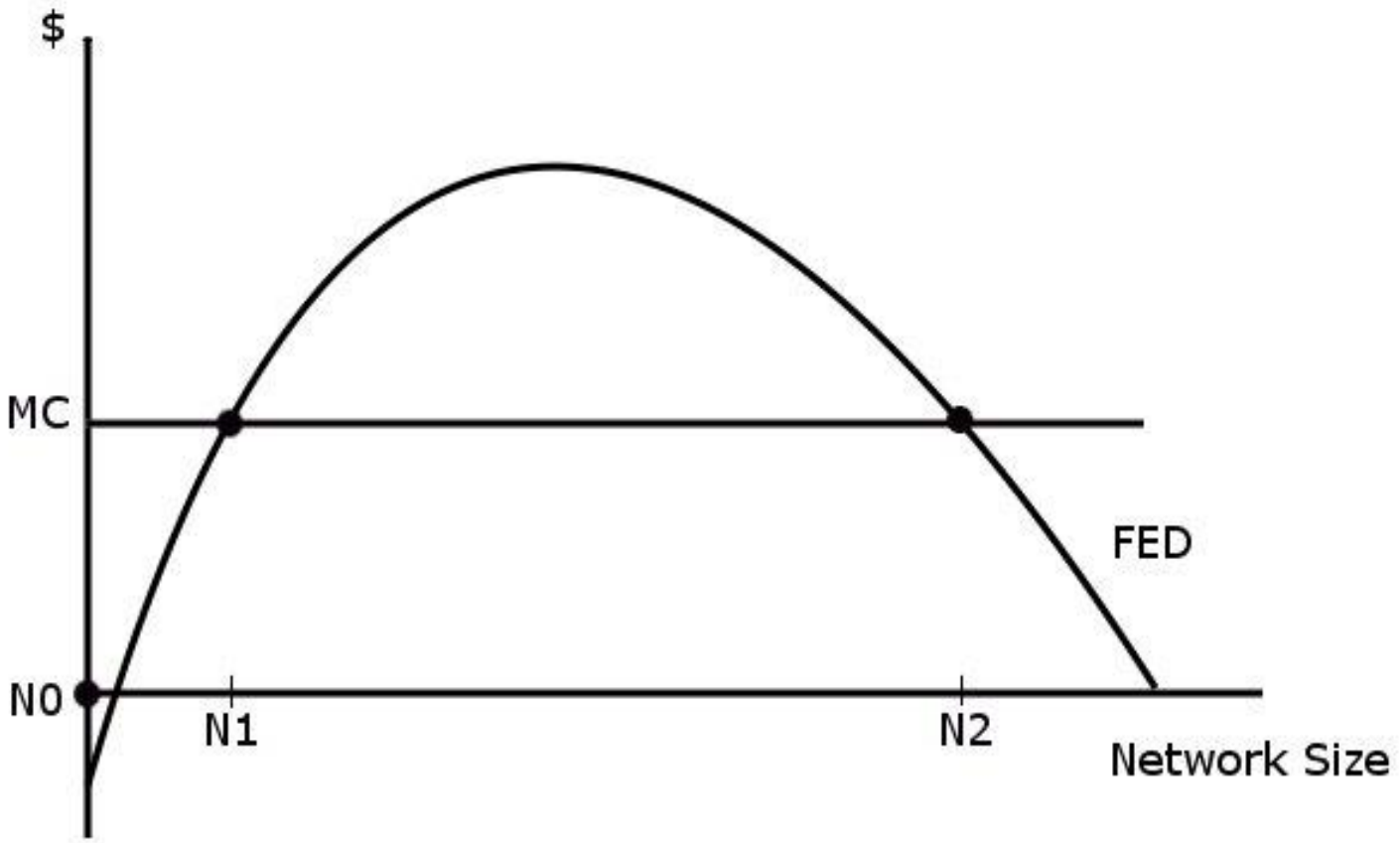
# Fulfilled Expectations Demand Curve

- 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: N0, N1, N2.

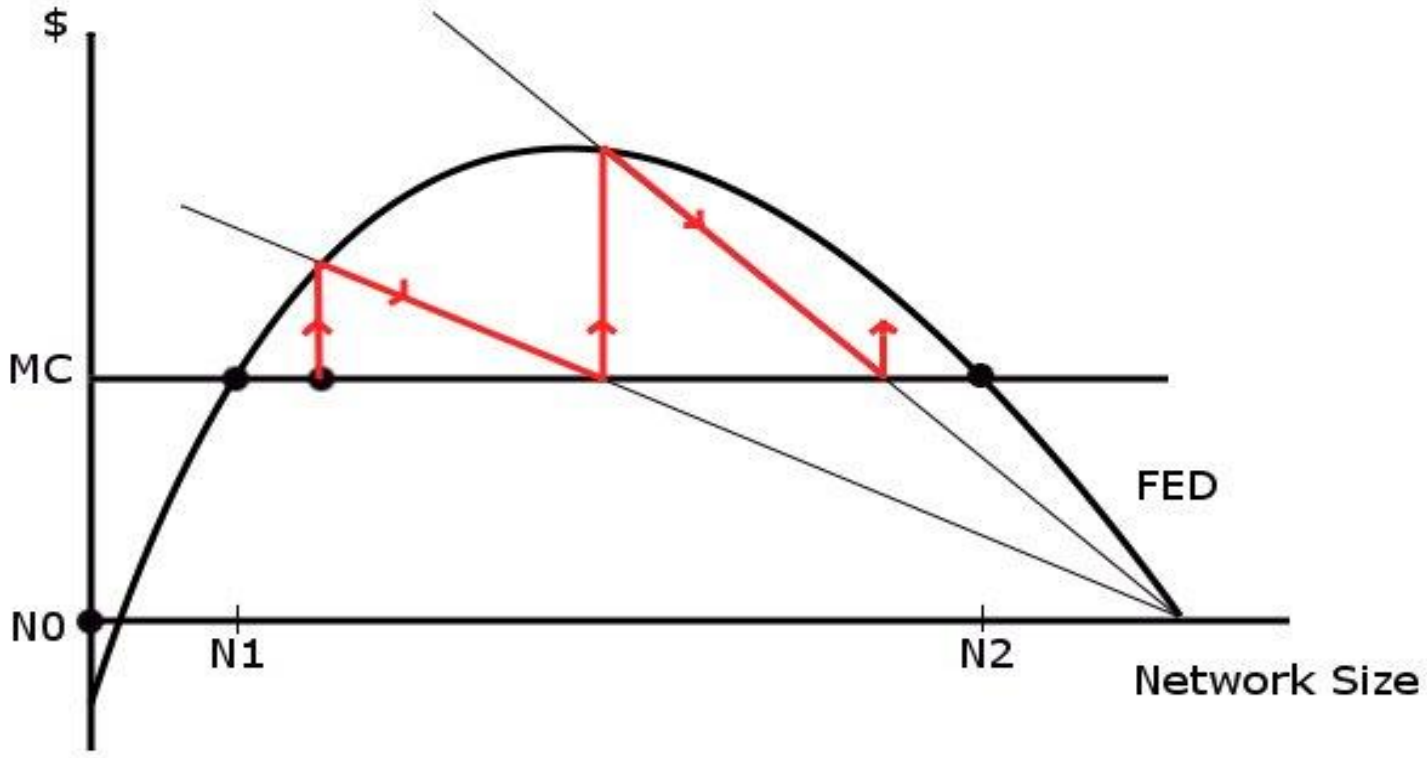


# Role of Expectations

- 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 N1 is unstable (called "tipping point")
  - If start with N>N1, get virtuous cycle: N →N2.

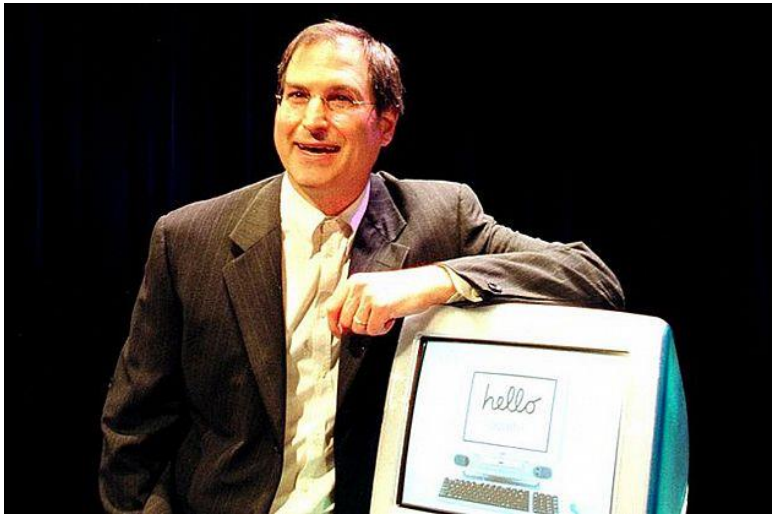


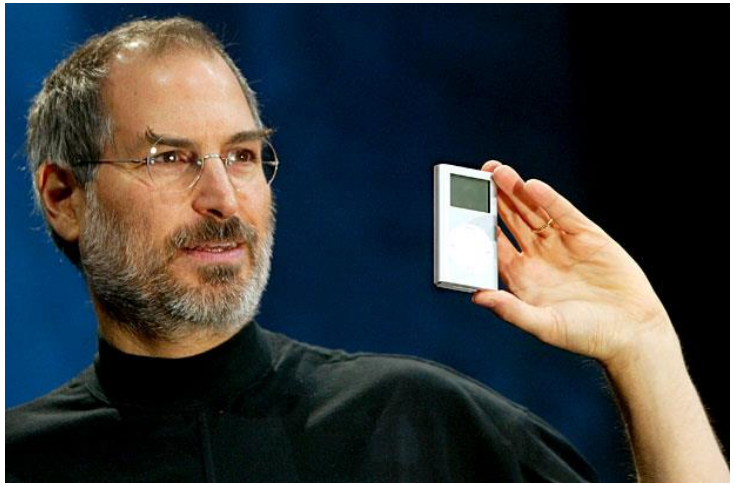

- Exercise: What happens if start with N<N1?

# What to do about Expectations?

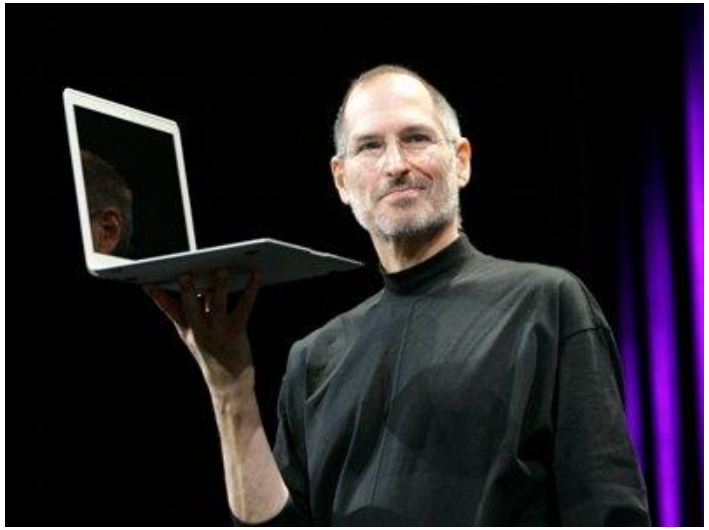
- Manage expectations directly
  - Product announcements (vaporware)
- Enable users to internalize externality
  - LinkedIn asks you to invite friends
- Give introductory discounts
  - Need network "sponsor" to have market power to overcome free-riding (unless all industry commits)
  - Risk of adverse 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

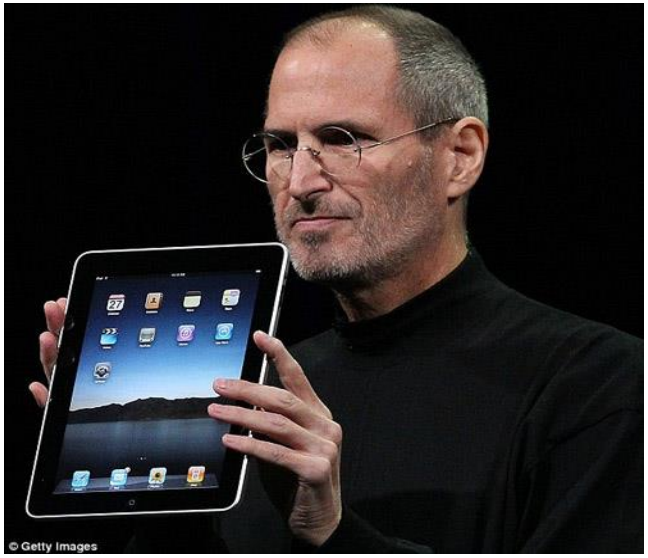
# Managing Expectations

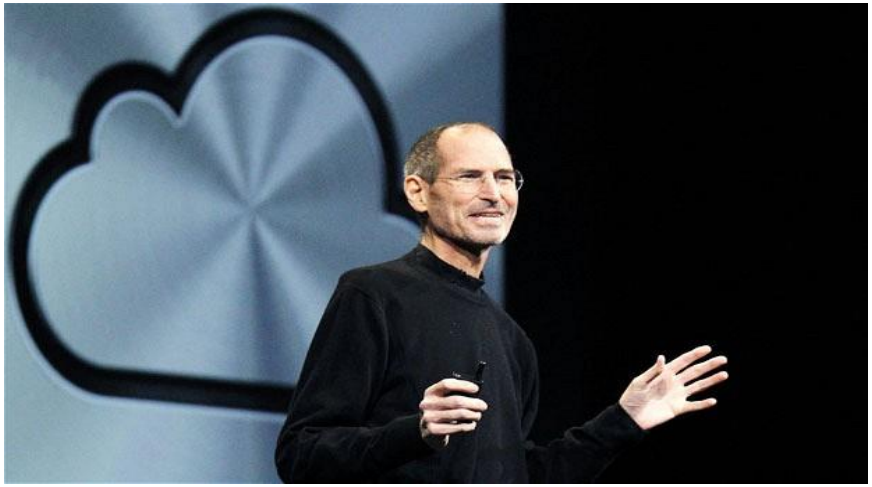



# Managing Expectations

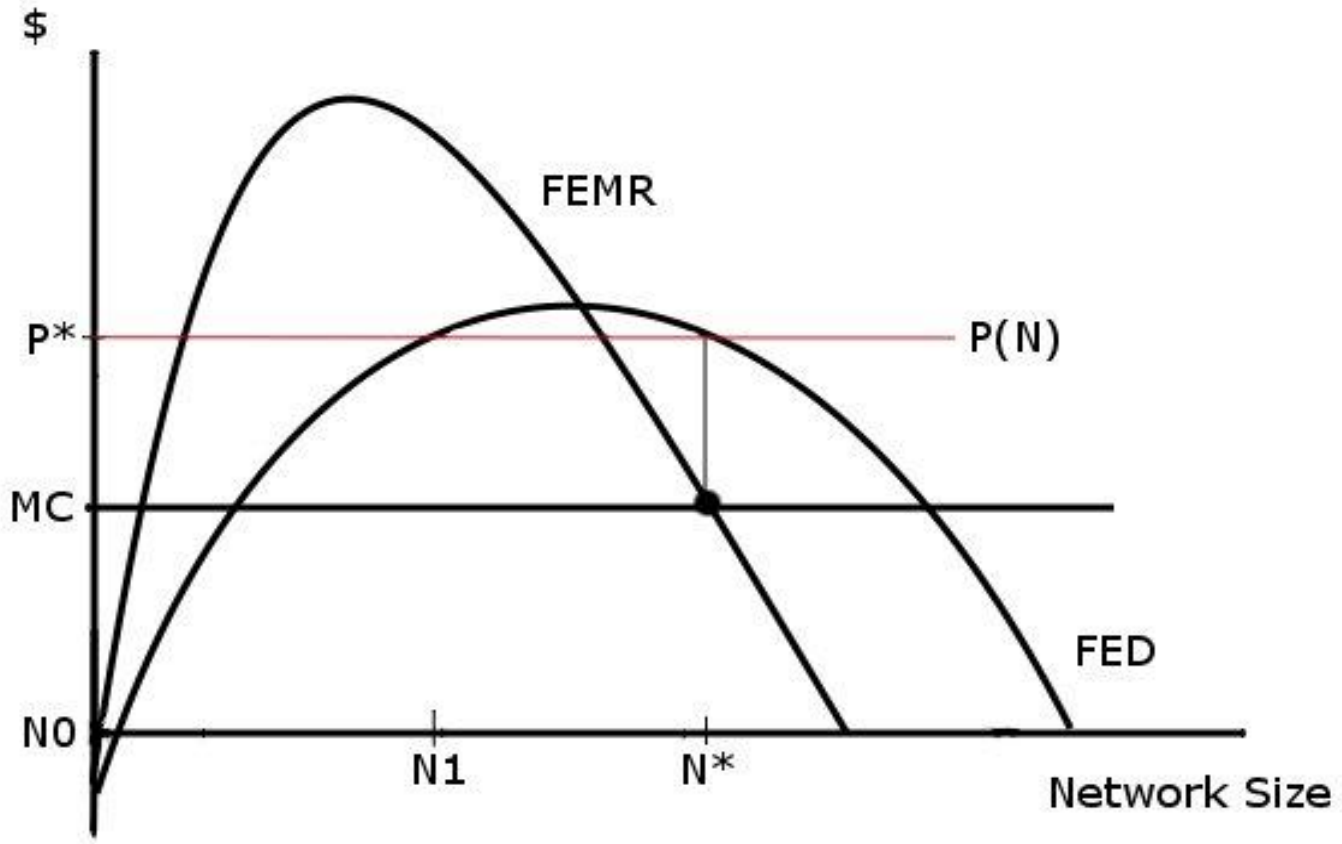




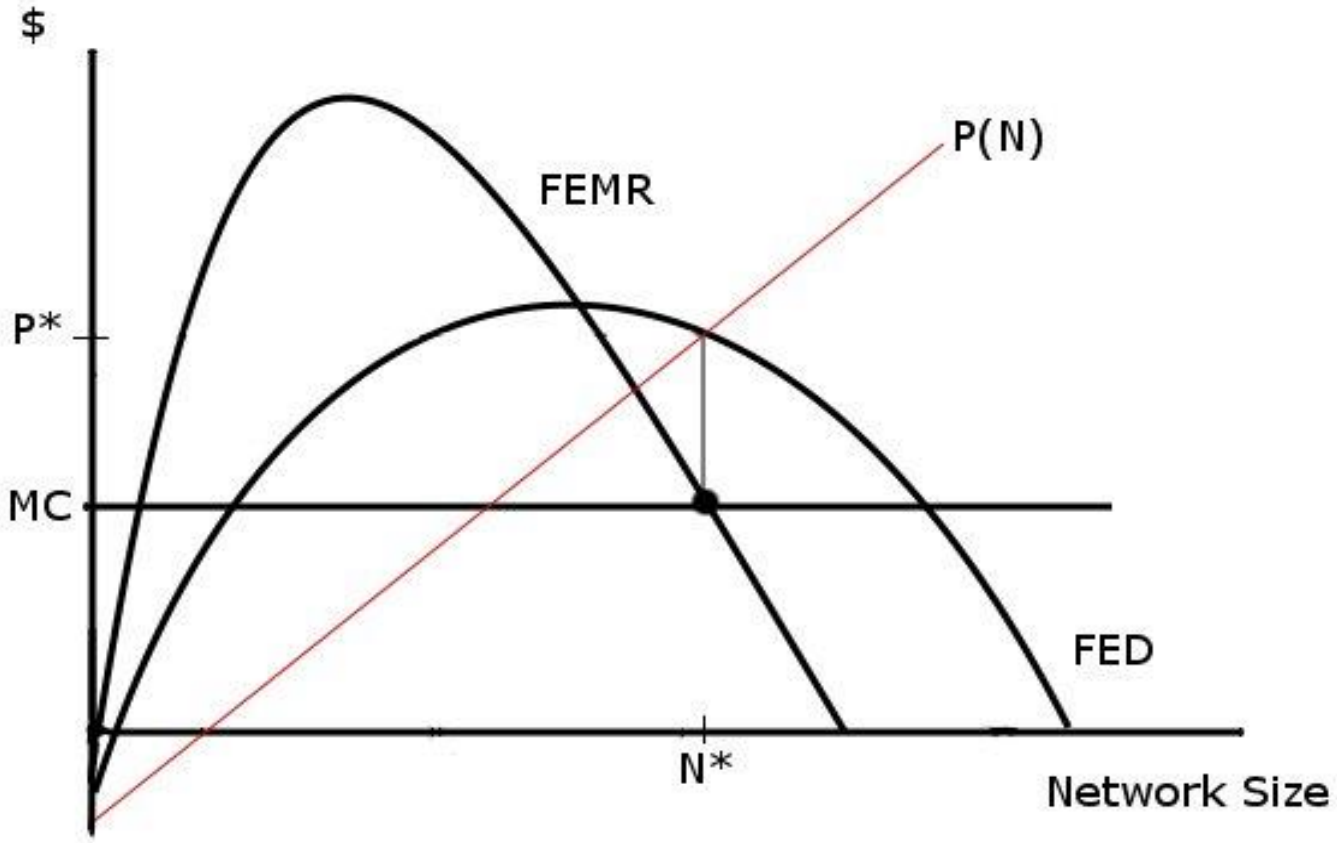
# Monopoly Pricing (e.g. Word, eBay)

- At optimal quantity N*, MR=MC. Yields price P*.
  - But if charge price P*, there are three equilibria: N0, N1, 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

$$p(n;n)+n\frac{\partial p(n;n)}{\partial n}+n\frac{\partial p(n;n)}{\partial n^e}=\frac{\partial c(n)}{\partial n}$$

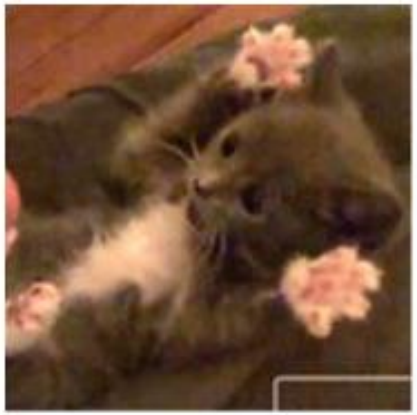
  - First and second terms – standard marginal revenue.
  - Third term – network effect, i.e. how increasing 'n' increases value of marginal user. Like an increase in marginal revenue.

# 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…

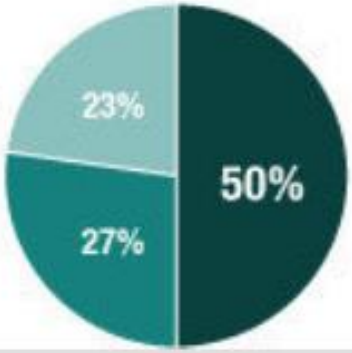


Kitten

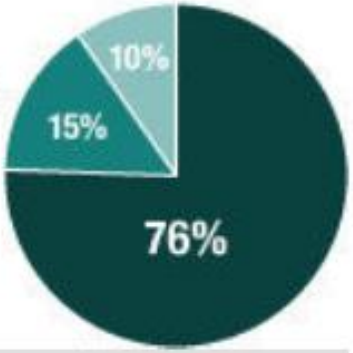
Slow Loris

Baby Polar Bear

Vote for the animal you think is the cutest.




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




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

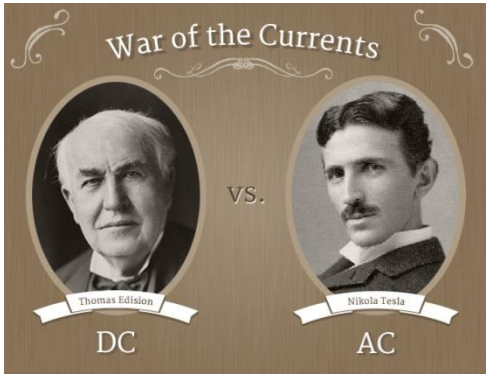
- Network effects act like collective switching costs
  - Small switching costs are magnified.
- Entrant comes into industry (e.g. Gchat)
  - Need people to switch in coordinated way.
  - Problem where there are positive homing costs.
- Example: QWERTY vs. Dvorak
  - Dvorak is better layout – typing 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)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# 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,…