Outline

• Waves of innovation
  - Combinatorial innovation
  - What are implications for commerce?

• Computer mediated transactions
  - There is now a computer between most buyers and sellers
  - What are the implications for business?

• Collaborative computing
  - There is now a computer in most offices
  - What are the implications for work?
Waves of innovation

- Huge innovation on web in the last 15 years
  - Web pages, search engines, wikis, docs, maps ...
    - Why has there been so much innovation?
    - Why has it been so rapid?
- Examples of combinatorial innovation
  - Set of component technologies that can be combined and recombined to create new innovations
    - 1800: Interchangeable parts
    - 1900: Gasoline engine
    - 1960: Integrated circuits
    - 1995-now: Internet
    - Shumpeter (1935), Usher (1929), Weitzman (1998), and others...
    - Often process takes years, or decades to play itself out, but this time it was very rapid
But this time…

- Component parts are all bits!
  - Protocols: TCP/IP, HTTP, CGI, Flash …
  - Languages: HTML, XML, Java, JavaScript ...
  - Software: LAMP (Linux, Apache, MySQL, Python)...
- Bits/protocols/languages can be combined to make…
  - Web pages, wikis, auctions, exchanges, video streaming, VOIP, search engines…
  - No time-to-manufacture, no inventory problems, no delivery problems
  - Bits can be shipped around the world in seconds, and innovators can work in parallel exploring combinations
- Result: extremely rapid evolution and technological progress
- Question: what are implications for commerce?
Computer mediated transactions

- A computer is now involved in almost every economic transaction
  - Even cash registers are just PCs with a special interface
  - B2B and web-based transactions are even more powerful due to direct connection to a database
  - Original intent of computer mediation was just accounting
  - But the record of transactions has other uses
  - How does the availability of computer-mediated transactions affect economic activity?
What are implications?

- What do computer mediated transactions enable?
  - Better contracts
  - Data extraction and analysis
  - Controlled experimentation
  - Personalization and customization
Better contracts

- Contracts are fundamental to commerce
  - Simplest form: “I will do X if you will do Y”
    - Exchange of goods, services, labor, ...
  - Major problem: monitoring the contract
    - Sometimes performance can be directly observed
    - But often the quality of goods, service, actions, effort may not be observed
    - Large literature in contract theory and mechanism design
- Where do computers come in?
  - Make more things observable and hence contractable
  - Historically, advances in “information technology” have often enabled better measurement and monitoring
  - Computers move this capability to a new level
Computer as accountant

• Since the computer serves as intermediary it can not only serve as an accountant but also be used to verify contractual performance
• Allows us to structure more elaborate contracts and potentially improve economic efficiency

Francesco di Marco Datini
Computer as monitor

- Since the computer serves as intermediary it can not only serve as an accountant but also be used to verify contractual performance.
- Allows us to structure more elaborate contracts and potentially improve economic efficiency.

Francesco di Marco Datini
Computer as verifier

- Since the computer serves as intermediary it can not only serve as an accountant but also be used to verify contractual performance.
- Allows us to structure more elaborate contracts and potentially improve economic efficiency.
- Accounting + computers = better monitoring = potentially better contracts.

Francesco di Marco Datini
Rental cars

• Assume...
  – Insurance for rental cars would cost less if renters drove more slowly
  – Drivers would be willing to drive more slowly if they paid less for rental car
  – But contract can not be made since driving speed can't be observed

• But now...
  – Contract is feasible due to vehicle monitoring technology
  – Everyone is made better off (in this model)
Historical examples

- Mediterranean shipping 3300 BC
- Cash registers 1883
- Semi trucks 1980s
- Video stores 1990s
- Online advertising 2000s
Mediterranean shipping 3300 BC

• How do you ensure that your full shipment is received at other end of voyage...with no written language?

• Answer
  - Match clay tokens (*bullae*) to jars of oil loaded on ship
  - Seal tokens in clay envelope, stamp clay with seal
  - Bake in kiln, send with shipment
  - At other end of journey, recipient breaks open the envelope and compares tokens to jars on ship
  - Later, inscribe marks on bullae as record of what is inside, which may have led to writing
Examples of bullae 3300 BC
How do you ensure employees don't steal?

- From cash register
  - Answer: put a bell on it
  - 1883 patent to James Ritty and John Birch for the “Incorruptible Cashier”
  - Paper tape + bell recorded transactions

- From truck
  - Put a “vehicular monitoring system” on it
  - Improves gas mileage, logistics, and honesty!
  - Hubbard (2000)
Video store rentals

- Originally store purchased video tapes from studio, rented to customers
  - But price was high, so store only bought a few
  - Much unhappiness among all parties
- Revenue sharing model
  - Distributor gives videos to store at nominal price
  - Each time one is rented, revenue is shared according to pre-specified formula
    - Dana and Spier (2001), Mortimer (2008),
- But need verifiable way to count the transactions
  - Use bar codes, computers, and network
  - Each party to the transaction can verify correctness on a daily basis
Align incentives in online advertising

• Publisher has space for ad impression on page, wants to sell it to the highest bidder
• Advertiser doesn't care about ad impressions, wants clicks = visitors and sales

• Answer
  – Value per impression = value per click x clicks per impression = VPC x CTR
  – CTR is the “exchange rate” you can use to convert one to the other. How to estimate?
  – Huge statistical/machine learning problem
  – Aligns incentives between publisher, advertiser and user

• Revenue sharing
  – Publisher and ad provider can share revenue from click
Example

### Advertiser
- Joe's Jets and Moe's Models both want keyword “jet airplane” but there is space for only one ad
- Joe is willing to pay a lot per click since he makes high profit selling jets
- But Moe gets a lot more clicks than Joe because more people buy models than real jets

### Publisher
- What publisher cares about is expected revenue = price per click \( \times \) expected number of clicks

### Ad network
- Tries to estimate expected number of clicks, which (typically) allows it to make a better choice of which ad to show
- So all major search engines estimate CTRs for ad ranking, allowing publishers to sell impressions and advertisers to buy clicks
Computer mediated transactions make advertising accountable

- A purchase can be linked back to a click or an impression, making advertising accountable
  - ...at least on a statistical basis
  - Allows for optimization and tuning of purchase process

- Examples
  - Search advertising
  - Contextual advertising
  - Display advertising
  - Mobile advertising
  - TV, radio, print more difficult due to lack of feedback
Data extraction and analysis

• Since online transactions are computer mediated, can study data for patterns
  – Which converts better [diamond] or [diamonds]?
  – How do clicks vary over time of day?
  – What keywords perform best?
  – What advertiser characteristics predict success?
• Build predictive and causal models
  – Formulate hypotheses
  – Build models and estimate parameters
• But you don't stop there...
Controlled experimentation

- Data from computer mediated transactions allows for measurement
  - But it takes controlled experimentation to determine causality
  - Online applications allow for controlled experiments and continuous improvement
  - “Process kaizen” in 1980s now becomes “product kaizen”
  - 6,000 experiments in 2009, 500 improvements on search alone
  - Data vs HiPPO
Customization and personalization

- Computer mediated transactions allow for “mass customization” whereby transactions can be optimized for individuals
- Purchases, searches, social interaction, etc.
- Most web ads are dynamically assigned

- Challenges
  - Benefits of personalization v privacy considerations
  - However interests are not diametrically opposed
    - Intended use: provide better services to users
    - Unintended use: fraud, extortion, embarrassment
    - Better security, information, transparency, user control can go a long way in aligning interests
But advertising is just the beginning...

- Computer mediated transactions make advertising accountable
- But computer mediated transactions also allow for other kinds of optimization
  - Logistics and transportation optimization
  - Customer feedback and interaction
  - Product design and evolution
  - Recommender systems
- Improves business processes across the board
- What are implications for worker-to-worker transactions?
“The computer and the dynamo”

- Paul David (1990) on the productivity of electricity
  - In early 1800s waterwheels powered plants
  - All machinery connected to central shaft
  - Clustered machinery by type as in model
Improvements in power

- Steam and then electric motors used same design
- Miniaturization of electric motor made it possible to power each machine separately
- Allowed for rearrangement of production...but no one did it. "We've always done it this way."
- Henry Ford and the assembly line offered the breakthrough
- Allowed for dramatic increases in productivity
Henry Ford and mass production

- Ford realized that he could rearrange production and assembly so as to optimize production
- Put the machines where they were needed, not where they “had always been”
Knowledge workflow

• Assembly of mechanical parts
  - Assembly lines: optimize the flow of physical product through factory in 1909

• Assembly of ideas
  - Collaborative computing: optimize the flow of ideas through the organization in 2009
    • Separation, distribution and optimization of tasks
    • Multiauthored documents to facilitate collaboration
    • Version tracking and control
    • Overcome barriers of distance
      - Outsourcing specialized tasks (McKinsey)
      - Adam Smith's pin factory for knowledge work
      - ...and on a global scale
Enabled by “cloud computing”

- Evolution of computing
  - Mainframe
    - Data was in one place but access was controlled
  - Networked workstation
    - Data in work group, direct access
  - Personal computer
    - Direct access, data mostly on single computer or LAN
  - Network computing
    - Data on network, direct access but mostly for download
  - Cloud computing
    - Direct access, data lives in cloud
    - Store once, read everywhere, write anywhere via the Web
    - Access from any device, at any time, by any authorized user
Infrastructure for rent

- Barriers to entry for online businesses have been dramatically reduced
  - Can purchase computation in data center, storage on demand, development environment and database services from cloud computing providers
  - Turns fixed cost into variable cost
  - Allows you to smoothly scale your business to meet customer growth
  - Pushes “combinatorial innovation” to a new level
    - Not only innovation is combinatorial, but now actual deployment!
    - Can foster a huge burst of creative activity
Micromultinationals

• Cheap communications
  – SMEs now have access to communications technology that only the mega-multinationals could afford a decade ago
  – Email, webpages, wikis, VOIP, wireless, collaborative computing, cloud computing
  – Opens doors to small business around the world

• Combinatorial innovation
  – Businesses can be born international
  – Fosters huge parallel innovation in both technology and commerce
  – This is only the beginning...
The End
Appendix

• Various unused slides below
Early attempt to optimize knowledge work with hypertext...
Disassembly line