“Disruptive Innovations & Technologies, 40 Years Lessons Learned”

Sept. 25, 2013

National Taipei University of Technology

Taipei, Taiwan

Paul I-Hai Lin, P.E. (IN, CA)

Professor of Electrical & Computer Engineering Technology

Purdue University Fort Wayne Campus

pilin@purdue.edu

http://www.etcs.ipfw.edu/~lin

Lessons Learned from Disrupted Innovations and Technologies (Electrical, Electronics, Computer, Communications & Networking, and Information Technology) of the last 40 Years, which Transform Life, Business, and Global Economy: the Only Constant is Change

Topics of Discussion

- Technology and Innovation
- Examples of Disruptive Innovations &Technologies
- Innovation Challenges in Established Companies
- Strategic Management of Technology: Integrating Technology and Strategy
- Conclusion

Technology: Definitions

- Terms Defines in Webster's New Collegiate Dictionary
  - Technology
    - Systematic treatment of a technical method of achieving a practical purpose
    - The totality of the means employed to provide objects necessary for human substance and comfort

Technology – Other Definitions

- "Four Meanings of Technology," *Science, and Technology, and Society*, by Robert E. McGinn, 1990, Prentice Hall
  - Technology as Technics
  - Technology as Technology
  - Technology as a Form of Human Cultural Activity
  - Technology as a Total Societal Enterprise
- Technology – from Wikipedia, http://en.wikipedia.org/wiki/Technology

Technology – Other Definitions

- Technology – refers to the theoretical and practical knowledge, skills, and artifacts that can be used to develop products and services as well as their production and delivery system.

Page 2, of [1]Robert A. Burgelman, Clayton M. Christensen, and Steven C. Wheelwright, *Strategic Management of Technology and Innovation, 5th edition*, McGraw-Hill, ISBN 0073381543, 2009.

History of Technology[1]

- Technology in Archaeology
  - Material technologies (stone tools, wood, pottery, copper, bronze, iron (steel))
  - Agriculture technologies
  - Information technologies (cave art, Venus figures, writing)
  - Energy technologies (fire, irrigation, sailing ships, wheeled vehicles)

[1]Fredrick Betz, *Managing Technological Innovation*, 2nd, John Wiley & Sons, Inc, 2003.

History of Technology[1]

- Transportation Technology
  - Horse, wheeled vehicles
  - Ship, stream boat, submarines
  - railroads, steam locomotive,
  - Cars, trucks
  - Air planes, rocket
- Energy Technology
  - Man power
  - Animal power
  - Wind power
  - Coal, steam power
  - Fossil fuel power

[1]Fredrick Betz, *Managing Technological Innovation*, 2nd, John Wiley & Sons, Inc, 2003.

History of Technology[1]

- Technology – Military Conflicts
  - Ancient warfare (weapons and armor; clubs, spears, knifes, bow and arrows)
  - Medieval warfare (military tactics, cavalry-based forces)
  - Gun power warfare (first developed in Song Dynasty, 960 – 1279, China)
  - Industrial warfare (mass-conscripted armies; rapid transportation – railroads, sea, and air; telegraph and wireless communications)
  - Modern warfare (variety of tools and methods available to modern battlefield commanders)

[1]Fredrick Betz, *Managing Technological Innovation*, 2nd, John Wiley & Sons, Inc, 2003.

All About Technology

- Technology Development Processes
  - Identification of a specific need
  - Assessment
  - Strategy, Funding, Plan, etc
  - Design
  - Prototyping
  - Transfer (Intellectual property)
- Commercialization
  - Production
  - Marketing
  - Sales
  - Distribution
  - Customer support
  - Maintenance
- User/customer/consumer

Classification of Technology

- State-of-the Art Technologies
  - Technologies equal or superior to competitive offering
- Proprietary Technologies
  - Technologies protected by patents, and so forth
- Known Technologies
  - Technologies common to many companies but used uniquely
- Core Technologies
  - Technologies essential for maintaining competitive positions

[2]Hans J. Thamhain , *Management of Technology*, John Wiley & Sons, Inc, ISBN 978-0-471-41551-0, 2005.

Classification of Technology

- Leveraging Technologies
  - Technologies that support several products or classes of products
- Supporting Technologies
  - Technologies that support core technologies
- Packng Technologies
  - Technologies that control the product or service development
- Emerging Technologies
  - Technologies under consideration for future application

[2]Hans J. Thamhain , *Management of Technology*, John Wiley & Sons, Inc, ISBN 978-0-471-41551-0, 2005.

Other Classifications of Technology

- Sustaining Technology
  - Improving on existing technologies, most often in the areas of performance
  - Compatible with existing standards and address current market needs
    - Examples
      - Microsoft Windows OSs
      - Windows 3.0, 3.1
      - Windows 95, 98
      - Windows 2000, XP, Vista
      - Windows 7
  - Palm's PDA; Pocket PCs, etc

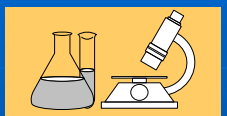
Other Classifications of Technology (cont.)

Specific Applications

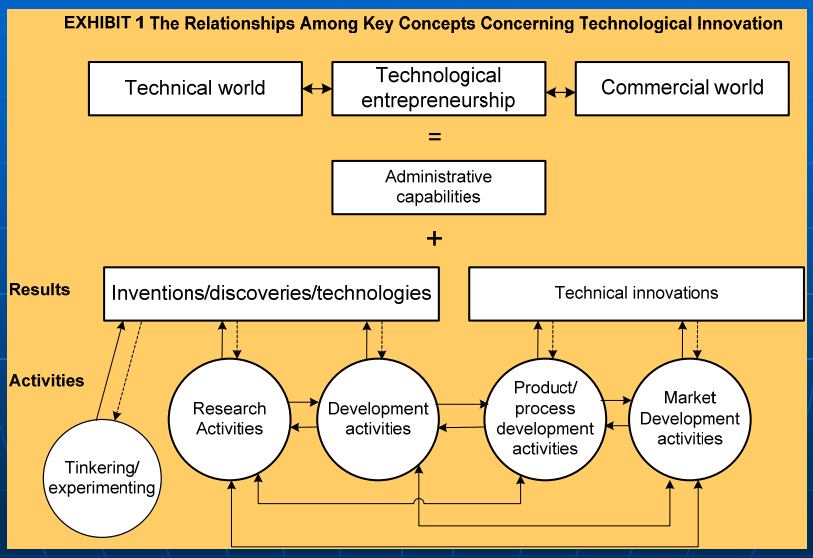
- Aerospace Technology
- Biological Technology
- Business Technology
- Computer Technology
- Energy Technology
- Information Technology
- Information Technology
- Material Technology
- Military Technology
- Medical Technology
- Transportation Technology
- Vehicular Technology
- Nanotechnology
- etc

Inventions/Discoveries/Technologies

- Inventions/Discoveries/Technologies
  - Inventions/Discoveries
    - Results of creative process
    - How to measure the success
      - Technical (Is it true/real?) rather than Commercial (Does it provide a basis for economic rents?)
      - Patents – allow their inventors/originators to establish a potential for success
      - Successful innovations (subsequent refinement may be needed, with significant time lag, 10 years or more)



Robert A. Burgelman, Clayton M. Christensen, and Steven C. Wheelwright, *Strategic Management of Technology and Innovation, 5th edition*, McGraw-Hill, ISBN 0073381543, 2009.



Technological Innovations

- Technological Innovations
  - **Technology-based Innovations**
    - Examples: disposable diapers, oversized tennis racquets, electronic fuel injection, personal computers
  - **Technology-facilitated Innovations**
    - Examples:
      - Business data processing & automation
      - ERP (Enterprise Resource Planning)
      - CRM (Customer Relationship Management.)
      - SCM (Supply Chain Management)

Technological Innovations

- Technological Innovations
  - Outcomes
    - New, marketable products and services and/or new production and delivery systems
  - Levels of Significance
    - Incremental innovations
    - Radical innovations
    - Architectural innovations

Technological Innovations

- Technological Entrepreneurship
  - Individual or corporate entrepreneurship
  - Activities
    - Create new resource combinations to make innovation possible, bringing together the technical and commercial worlds in a profitable way
  - Administrative capabilities: efficient, effective

Disruptive Technology

- Disruptive Technology
  - Andy Grove, Intel co-founder, define its as “a time in the life of a business when its fundamentals are about to change”
  - The needs of the customer can no longer met inside the current technology parameters
  - Radical change at a system level with paradigm-shifting innovations
  - Huge positive impact on the economy, new categories of products and services, new companies and jobs

Examples of Disruptive Technology

- Transistor-based devices
  - Battery-powered transistor radio introduced by Sony in 1950
  - Over time, the transistor radio became cheaper, smaller, and better quality of sound
- Integrated Circuits
  - Microprocessor (MOS-based) in 1970's
  - Microcontrollers
  - Intel CPUs for PCs

Examples of Disruptive Technology

- Personal Computer
  - Disruptive to
    - The mini-computer industry (DEC, Wang Computer)
    - The companies making terminal connect hardware
    - Altered paradigm: a computer on every desk vs. a computer in every office
- Storage Devices
  - Magnetic memory/RAM/DRAM
  - Floppy disk/Zip Disk/Flash Drive

The Disruptive Innovation Example - Microprocessor

- Invention of Microprocessor
  - In the November 1971, Intel announced the first microprocessor Intel 4004 to the world, http://www.intel.com/museum/archives/4004.htm
  - Busicom eventually sold some 100,000 calculators

Intel® 4004 microprocessor

Busicom* 141-PF printing calculator

The Disruptive Innovation Example - Microprocessor

- Intel Museum http://www.intel.com/content/www/us/en/company-overview/intel-museum.html
  - **1972: 8008 Microprocessor**
  - **1974: 8080 Microprocessor, (8085)**
  - **1978: 8086-8088 Microprocessor**
  - **1982: 286 Microprocessor**
  - **1985: Inetl386™ Microprocessor**
  - **1989: Intel486™ DX CPU Microprocessor**
  - **1995: Intel® Pentium® Processor**
  - **1997: Intel® Pentium® II Processor**
  - **1998: Intel® Pentium II Xeon Processor**
  - **1999: Intel® Celeron® Processor**
  - **2003: Intel® Pentium® M Processor**
  - **…**
  - **2012 ...**
  - **2013…**

Examples of Disruptive Technology: Internet Technology

- Computer-computer communications
- Collaboration, resource sharing
- Information sharing/publishing
- E-learning and education
- Advertisement
- Business automation
- Communications
- E-business/E-commerce
- Online Services, Social networking
- Cloud-based Computing
- Internet of Things
- Energy Network (Smart power grid)

Innovation Challenges in Established Companies

- The Managerial Challenges (SAP - 1970)
- The Use of New Venture Divisions
- A Framework for Assessing Internal Entrepreneurial Initiatives
- Design Alternatives for Corporate Entrepreneurship
- Choosing Design Alternatives
- Implementing Design Alternatives

Managing Corporate Entrepreneurship

Choosing Design Alternatives

- Exhibit 7: 9 Design Alternatives
  1. **Direct Integration**
  2. **New Product Department**
  3. **Special Business Units**
  4. **Micro New Venture Department**
  5. **New Venture Division (NVD)**
  6. **Independent Business Units**
  7. **Nurturing plus Contracting**
  8. **Contracting**
  9. **Complete Spin-Off**

Managing Corporate Entrepreneurship

EXHIBIT 7 Organization Designs for Corporate Entrepreneurship

Operational relatedness	Very important	Uncertain	Not important
Unrelated	3 Special business units	6 Independent business units	9 Complete Spin-off
Partly related	2 New product development	5 New venture division	8 Contracting
Strongly related	1 Direct integration	4 Micro new venture department	7 Nurturing and contracting

Strategic importance

Source: R. A. Burgelman, "Designs for Corporate Entrepreneurship in Established Firms," California Management Review (Spring 1984), pp. 154-166.

Technological Competence and Capability

Distinctive Competence

- Technological and production expertise
- Differentiated skill
- Complementary assets
- Routines, processes used
- Marketing

Core Competence

- Provide potential access to a wide variety of markets
- Make significant contribution to the perceived customer benefits of the end product, and
- Be difficult for competitors to imitate

GTE vs. NEC: Core Competence

GTE
1918 - 2000

- General Telephone & Electronics Corp.,
- Industry: Telecommunications
- Fate: Merged with Bell Atlantic
- Successor: Verizon Communications
- Founded: 1918
- Defunct: 2000

GTE, http://en.wikipedia.org/wiki/GTE

GTE vs. NEC: Core Competence

NEC 1980 - 1990s

- Founded 1899
- 1970's Strategic Intent: Convergence of Computer & Communications (C&C)
- 1980: Sales $3.6 billion, GTE comparable technological base and computer business
- No experience as an operating telecommunications company

NEC 2010

- 1988: World leader in semiconductor, and 1-st tier player in telecommunications products and computers
- Consolidates its position in mainframe computers
- Consumer electronics: mobile phones, fax machines, laptop computers

www.nec.com

NEC R&D : 2011/9/22
http://www.nec.co.jp/rd/en/

NEC 2011 & 2012 Products

2011

- Computing Products
- Display Solutions
- Software
- Telecom Network
- Social Infrastructure
- Electron Devices

2012

- Computing Products
- Display Solutions
- Software
- Telecom Network
- Social Infrastructure
- Electron Devices
- Enterprise Network and Communication

NEC 2013: Products (Common)

- Broadcast Products
- Business Computers
- Fiber Optic Devices
- Integrated IT Infrastructure
- Monitors and Projectors
- Network Products
- Outsourcing
- Sensor & Camera
- Server
- Social Infrastructure
- Software
- Storage
- Systems

http://www.nec.co.jp/en/global/solutions/index.html?
NEC Products:

NEC Global R&D 2013

NEC 2013

- C & C Innovation (since 1977)
- Knowledge Discovery
- Cloud System
- Information & media Processing
- Smart Energy
- Green Platforms

NEC R&D :
http://www.nec.co.jp/en/global/rd/index.html/

What is Technology Strategy?[1]

- **Firm's approach to the development and use of technology strategy**
  - The creation of a unique and valuable position, involving a different set of activities
  - Making trade-offs in competing
  - Creating fit among a company's activities
- **Must address three broad issues:**
  - What technology to develop
  - Whether to seek technological leadership in those technologies
  - The role of technology licensing

[1]**"What is Strategy?" Michael E. Porter, *Harvard Business Review*, Nov-Dec, 1996**

Substance of Technology Strategy

1. **Technology Deployment**
2. **The Use of Technology in firm's value chain**
3. **The Firm's Resource Commitment to various areas of technology**
4. **The Firm's use of organization design and management techniques to manage the technology function**

Technology Choices

- Careful assessments: technology, market factors, and targets
- A room fan example (technology choice)
  - Core design concepts: move air
  - Implementations: manual or electrical power
  - Designing and building motors (components): require EE & ME knowledge
  - A product (dominant design): architecture that determine how its components fit and work together
  - Control and monitoring options: wired, wireless, Internet



Integrating Technology and Strategy:
Connecting Technology & Strategy

- During the 1980s, technology is recognized as an important element of business definition and competitive strategy
- Abell: "technology adds a dynamic character to the task of business definition, as one technology may more or less rapidly displace another over time."
- Porter observes that technology is among the most prominent factors that determine the rule of competition
- Friar and Horwitch explain the growing prominence of technology as the result of historical forces

Integrating Technology and Strategy: Connecting Technology & Strategy (cont.)

- **Technology and Competitive Strategy**
- **Porter's "generic strategies", 1985**, – a framework for classifying competitive strategies: Technology Strategy

a) Industry-wide differentiation (broad range of industry segments)
   - Quality, performance, features, delivery, supports, etc
   - Better products, services

b) Focused differentiation (a narrow set of industry segments)
   - Customers' willingness to pay a premium price

c) Industry-wide cost leadership
   - Lower price, comparable products & services

d) Focused cost leadership (a narrow set of industry segments)
   - Lower delivering cost infrastructure

Integrating Technology and Strategy: Connecting Technology & Strategy (cont.)

- Technology Portfolio
  - Technology Life Cycle
  - Technology Importance
    - Value it brings to a particular class of products
    - Value it could potentially bring to other classes for the customer/user
  - Relative Technology Position (reference to competitors)
    - Patent position, know-how and trade secrets, learning curve effects, and key talent
    - Strongly affected by the firm's historical and future levels of investment

Integrating Technology and Strategy: Connecting Technology & Strategy (cont.)

- Technology Portfolio and Business Portfolio
  - Companies
    - Has multiple businesses in their corporate portfolio, each with its own technologies
  - Portfolio planning tool - McKinsey's framework based on industry attractiveness and competitive position dimensions
  - Harris, Shaw, and Somers suggest examining the relationship between
    - Traditional portfolio planning matrix
    - Technology portfolio matrix

Integrating Technology and Strategy: Technology Evolution and Forecasting

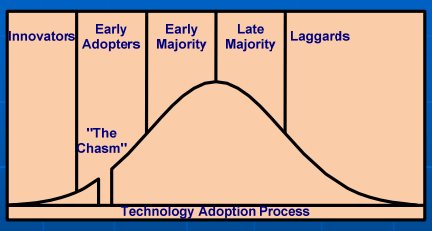
- Technology Product Life Cycle
  - Technology change affecting firm's competitive position
  - Firm find it difficult to respond to such changes
  - Integrating technology & strategy
    - Understand life cycle of various technologies it employs
    - Potential for competitive advantage

Assessing Innovative Capabilities

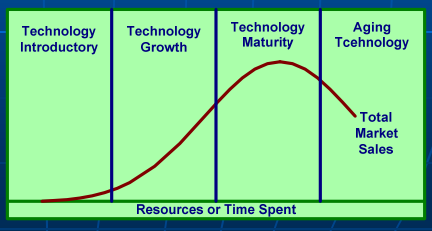
- Persons – who responsible for managing the innovation process
- Firm's innovative potential and into the barriers to innovation
- Decisions on Innovations: managerial attention, resources
- Innovation capabilities **audit** (address at least 3 questions)
  - How has the firm been innovative in the areas of product and service offering and/or production and delivery systems?
  - How good is the fit between the firm's current business and corporate strategies and its innovative capabilities
  - What are the firm's needs in terms of innovative capabilities to support its long-term business and corporate competitive strategies?

Evolutionary Forces Shaping Technology Strategy: Technology Evolution

- Technology Adoption Cycle



- Technology S Curve



Substance of Technology Strategy

- **Technology Leadership**
  - Pioneering role vs. Monitoring role
    - Product market strategy
  - Cannon Technology, 2011: **http://www.canon.com/technology/**

Canon History: **http://www.canon.com/about/history/05.html**

EXHIBIT 3 Core Competencies at Canon

	Precision mechanics	Fine optics	Micro-electronics
Basic Camera	■	□	
Compact fashion camera	■	□	
Electronics camera	■	□	
EOS autofocus camera	■	□	■
Video still camera	■	□	■
Laser beam printer	■	□	■
Color video printer	■		■
Bubble jet printer	■		■
Basic fax	■		■
Laser fax	■		■
Calculator			■
Plain paper copier	■	□	■
Battery PPC	■	□	■
Color copier	■	□	■
Laser copier	■	□	■
Color laser copier	■	□	■
NAVI	■	□	■
Still video system	■	□	■
Laser imager	■	□	■
Cell analyzer	■	□	■
Mask aligners	■		■
Stepper aligners	■		■
Excimer laser aligners	■	□	■

Every Canon product is the result of at least one core competency.

** Reproduced from reference [1], page 76.

Canon's Technologies: 2011

http://www.canon.com/technology/sitemap.html

- Elemental (Key) Technologies
  - Color Management Technology
  - Communication Network Technology
  - XML Technology
  - User Interface Platform Technology
  - Image Retrieval Technology
  - DRYOS (Real-Time Embedded Operating System)
- Elemental (Key) Technologies
  - System LSI Integrated Design Environment
  - Simulation Technologies
  - In-Process Visualization Technology
  - Encoders
  - Laser Doppler Velocimeter
  - Galvano Scanner
  - Micro Laser Interferometer
  - Ultrasonic Motor

Canon's Technologies: 2011

- Environmental Technologies
  - High-Performance Bio-Based Plastics
  - Technologies for Replacing Volatile Organic Compounds
  - Ozone-Free Electrical Charging Technology
  - Toner Fixing Technology
  - Energy Conservation Technologies
- Future Technologies
  - AISYS (Aspectual Illumination System)
  - Mixed Reality Technology
  - SED (Surface-Condition Electron-emitter Display)
  - Organic LED Displays

Conclusion

- Past & current success – Lessons learned
- What actions?
  - When confronted with the threat of radically new technology (switch to new technology, improved existing technology? 5.25 inch disk vs. 14 inch disk drive)
  - Faced with architectural innovations (Example: CICS vs RISC computer architectures)
  - Getting into the new areas of business
  - Corporate R&D capabilities

Evolutionary Forces Shaping Technology Strategy

1. Five Major Forces [2]: Industry Competitors, New Entrants, Buyers, Suppliers, Substitutes
2. Appropriability Regime associated with a technological innovation (Teece, 1986)
3. Complementary Assets needed to commercialize a new technology (Teece, 1986)
4. Emergence of dominant designs
5. Increasing returns to adoption
6. Emergence of industry standards
7. Social systems aspects of industry development
8. The competitive effects of the interplay of social systems characteristics and technological change