INFO4444 Computing 4 Innovation

Week 2: Innovation Frameworks I – Dynamics of IT Innovation & Dominant Design

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Dynamics of IT Innovation

Section 1

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Diffusion of Innovation
Section 1.1

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Diffusion of innovation

**Everett Rogers**, Sociologist and communications scholar (1931 – 2004)

Hybrid seed corn

Image: burpee.com

- Originally a rural scholar studying agricultural innovations

- Interested in why some farmers adopted new innovations and some others didn't

- Some farmers didn't adopt innovations even if economically sensible

Diffusion of innovation

– Influential book: "Diffusion of Innovations" (1962), 5th edition (2003)

– "New ideas tend to follow a pattern in entering society"

– The concepts are still widely used by governments and companies in understanding, planning and influencing adoption of new products
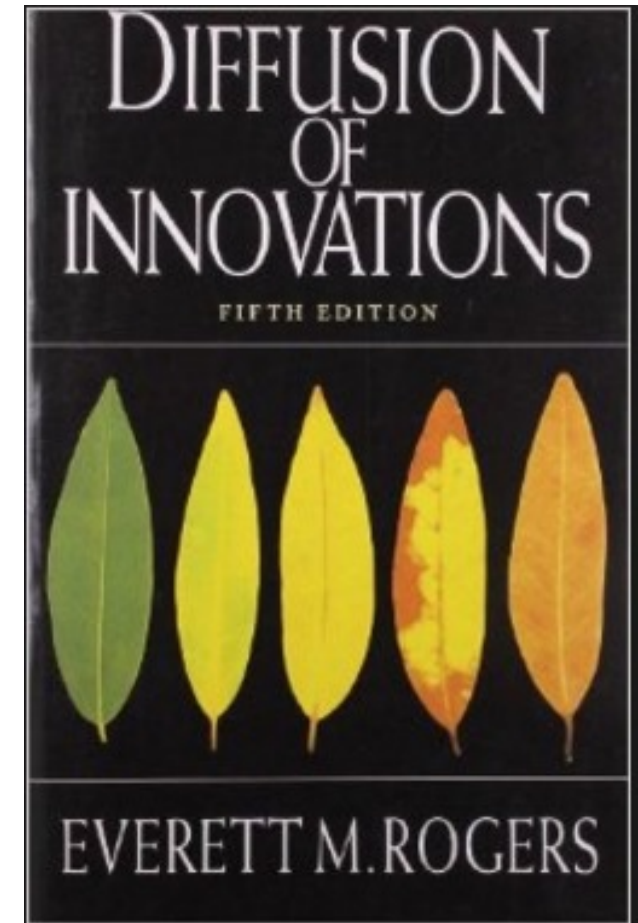
The Innovation-Development Process

Stages in the Innovation-Development Process:

 (not always all used and not necessarily in this order)

1. Recognising a problem or need
2. Basic and applied research
3. Development
4. Commercialisation
5. Diffusion and adoption:
    –   Spreading innovation through members of a social system
6. Consequences

Source: Rogers (2003)

Diffusion of innovation

– **Definition:** "Diffusion is the process in which an innovation is communicated through certain channels over time among the members of a social system." (Rogers, 1962)

Diffusion of innovation

A product innovation, process innovation, business model innovation etc

By word-of-mouth, TV, trade journals, Internet, Social Media, etc.

"Diffusion is the process in which (1) **an innovation** is (2) **communicated through certain channels** (3) **over time** among (4) the **members** of a (5) **social system**."

This is the "rate of adoption" of an innovation.

There are different types of people – some tend to adopt innovations early after initial availability, others later.
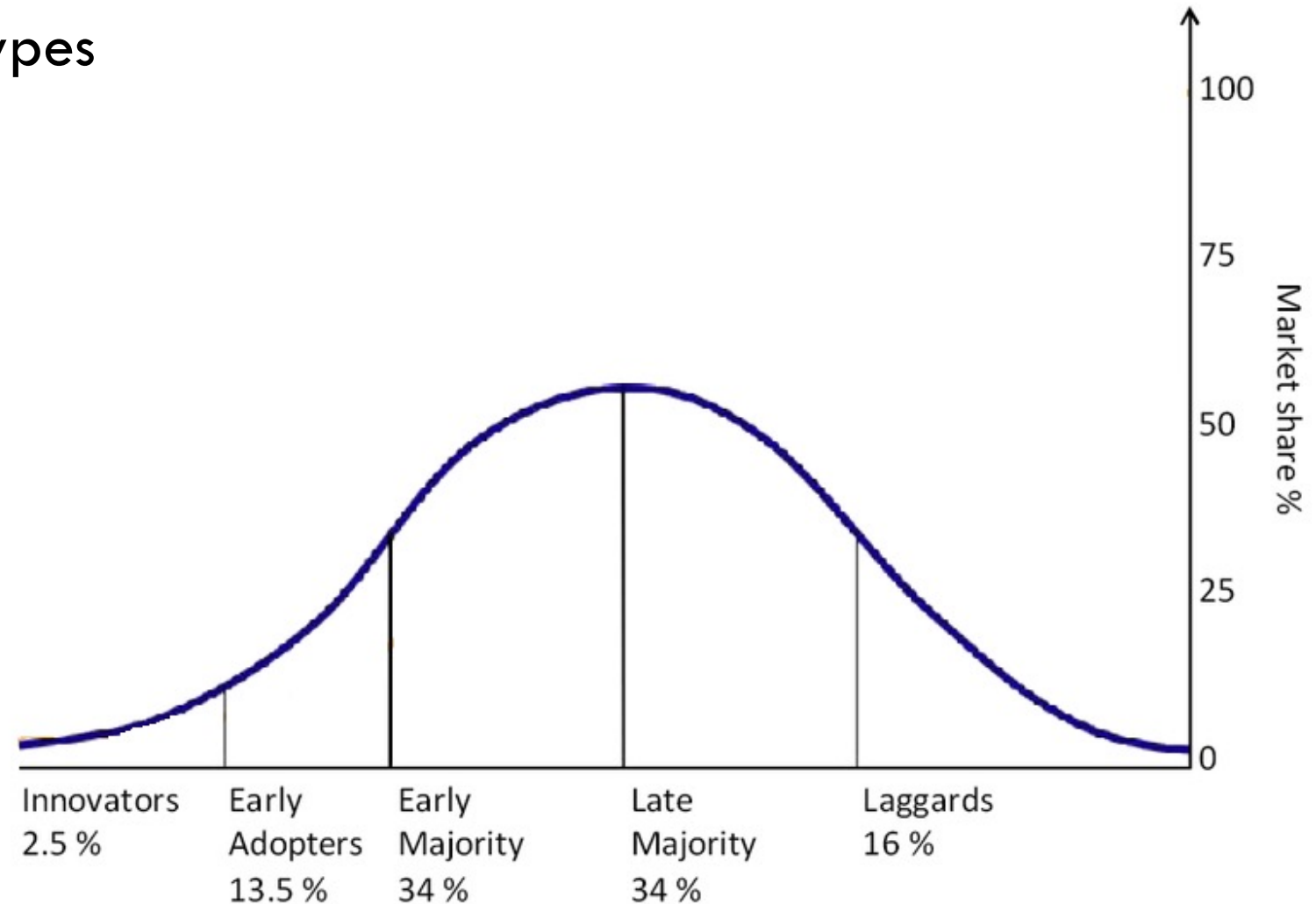
A social system has external influencers (eg media, govt) and internal influencers (eg opinion leaders)

Technology Adoption Lifecycle Model
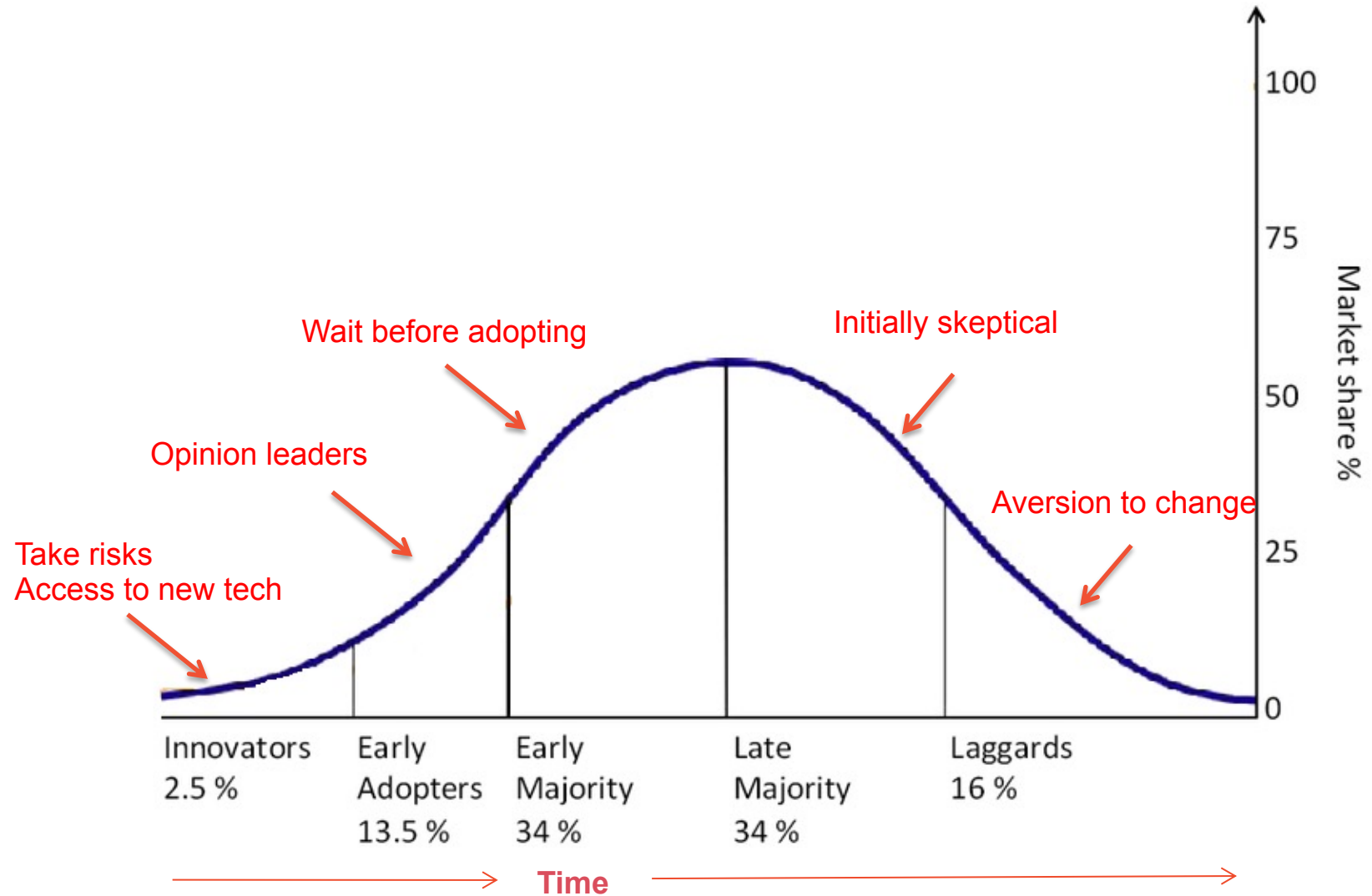Section 1.2

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Technology Adoption Lifecycle Model

- Rogers identified 5 types of adopters

- Each has specific characteristics

Technology Adoption Lifecycle Model

Which type of adopter are you?

"The Chasm"

- From "Crossing the Chasm" book by Geoffrey Moore
- Challenging to get from early adoption to mainstream and provides approaches to help
- Cross the chasm → greater opportunity for dominance in the market

Geoffrey Moore,
High tech consultant

The *Revised* Technology Adoption Life Cycle

Innovators Early Adopters Early Majority Late Majority Laggards
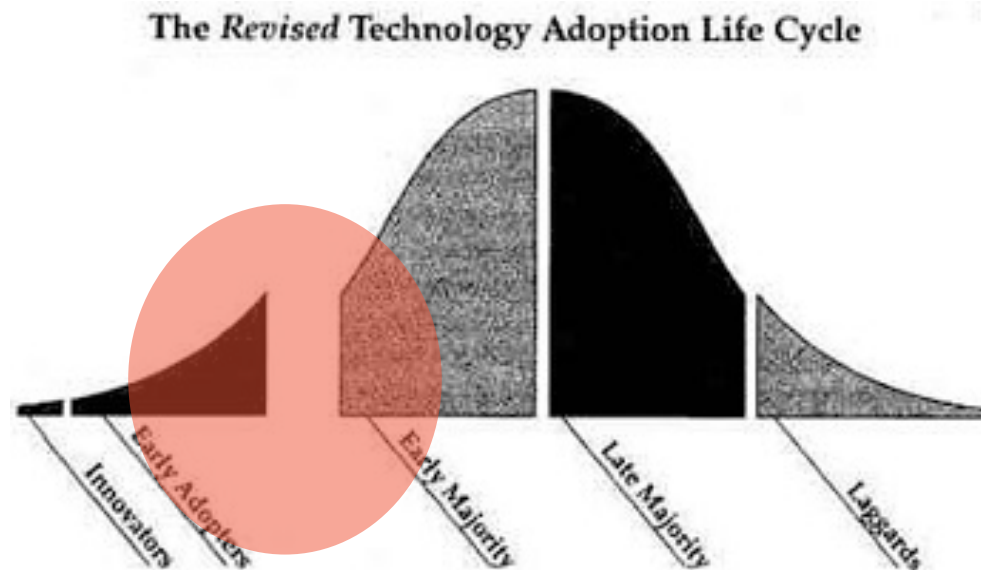
Figure from "Crossing the Chasm"

"The Chasm"

– Many new technologies fail because they cannot "cross the chasm" --> they fail to gain traction in the mainstream market after appealing to early adopters.

– **Early Adopters** are willing to take risks and experiment, but the **Early Majority** needs proven, reliable, and practical solutions before they adopt.

How To Cross "The Chasm"?

– To move from early adopters to the mainstream market, Moore suggests:

1.Narrowing the focus (Target a niche first)

Example: Tesla initially targeted the luxury EV market before expanding to mass-market vehicles.

2.Positioning the product as a practical solution

Example: Cloud computing services gained traction in businesses after case studies showed cost savings and scalability.

3.Building a strong reference base

Example: Microsoft's Windows OS gained credibility when IBM adopted it for PCs.

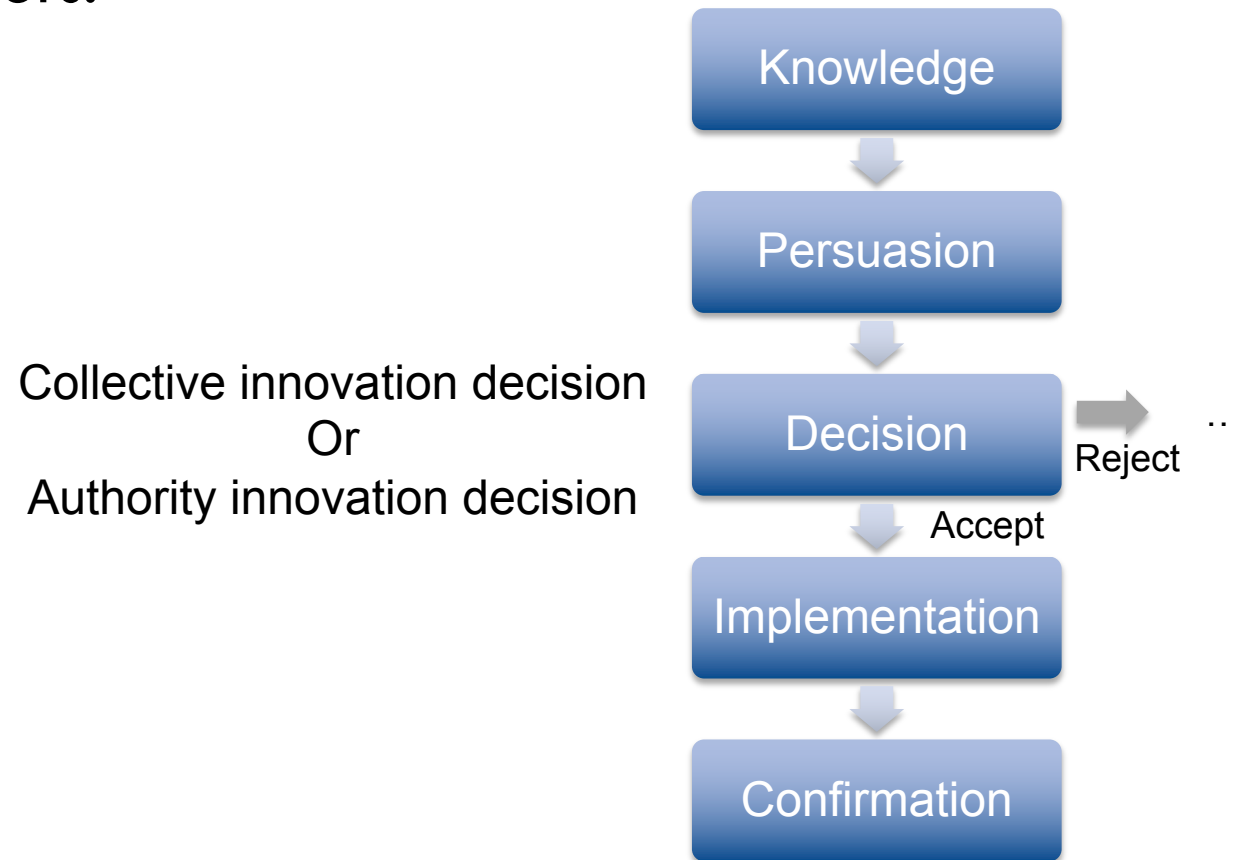## 4.Developing a complete product (not just an innovation)

Example: Smartphones only went mainstream after app ecosystems, security updates, and seamless connectivity improved.

5.Using a "Bowling Alley" strategy

Example: Amazon started with books, then expanded into electronics, cloud computing (AWS), and more.

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The process of innovation adoption: Adoption by Individuals or Organisations

– From Rogers:

Knowledge

⬇

Persuasion

⬇

Decision → ... Reject

⬇ Accept

Implementation

⬇

Confirmation

Collective innovation decision
Or
Authority innovation decision

Rate of adoption of an innovation

- Perceived attributes of innovations that determine rate of adoption:

  - **Relative advantage** – better than the idea it supersedes?

  - **Compatibility** – consistent with the existing values, past experiences, and needs of potential adopters?

  - **Simplicity** (vs Complexity) – simple to understand and use?

  - **Trial-ability** – can be experimented with on a limited basis (low cost, "free trial")

  - **Observe-ability** – results of an innovation are visible to others, who imitate?

- Rate also affected by:

  - Change Agents' Promotion Efforts (eg. marketing)

  - Other factors (social influence, economic environment . . .)

Source: Rogers (2003)

Can you explain the failure (slide 18)?

Innovations do not always diffuse successfu

- QWERTY keyboard layout:
  - Designed for typewriters (1873)
  - Common key pairs far apart
  - Very slow
- Dvorak keyboard layout:
  - Typewriters had improved so no longer jammed
  - People tried for a new keyboard design for faster typing
  - Dvorak layout design (1932)
  - Reducing finger movement
  - Significant improvements in speed
  - Not widely adopted

Key jam
image: pipeandgrumble.blogspot.com.au

Dvorak keyboard

Can you think of other examples of failus?

– What are the reasons?

Gartner Hype Cycle
Section 1.3

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Interpreting Technology Hype
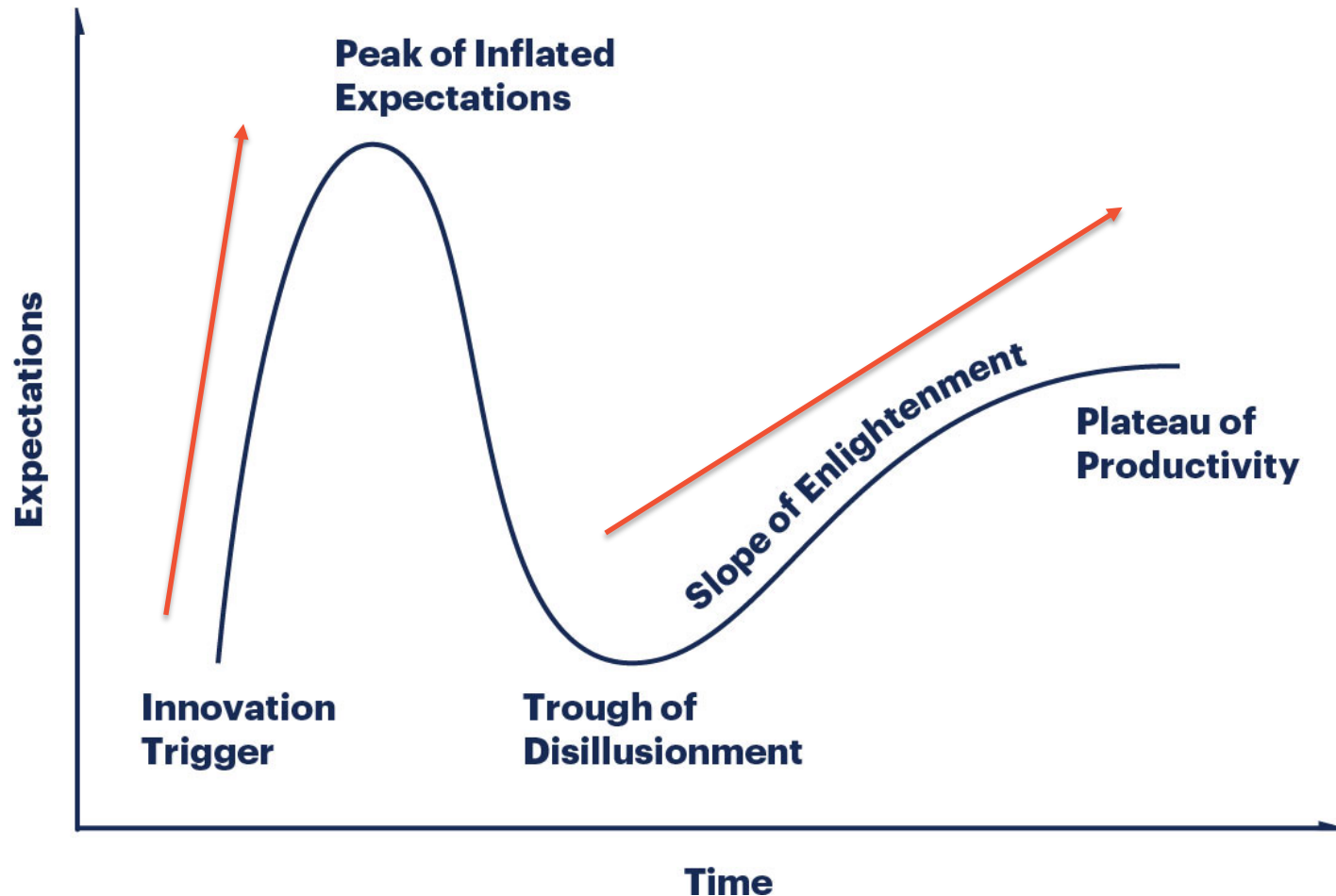
Most innovation go through a pattern of overenthusiasm and disillusionment, followed by eventual productivity. (initial excitement, disappointment, and eventual stability)

Describes how expectations surge and contract over time as an innovation progresses (expected value)

Two stages of upward direction:

1. Driven by market hype. High expectations met with low maturity.

2. Driven by increase in maturity of the innovation. Leads to real value and fulfilled expectations

Five phases of a technology's life cycle

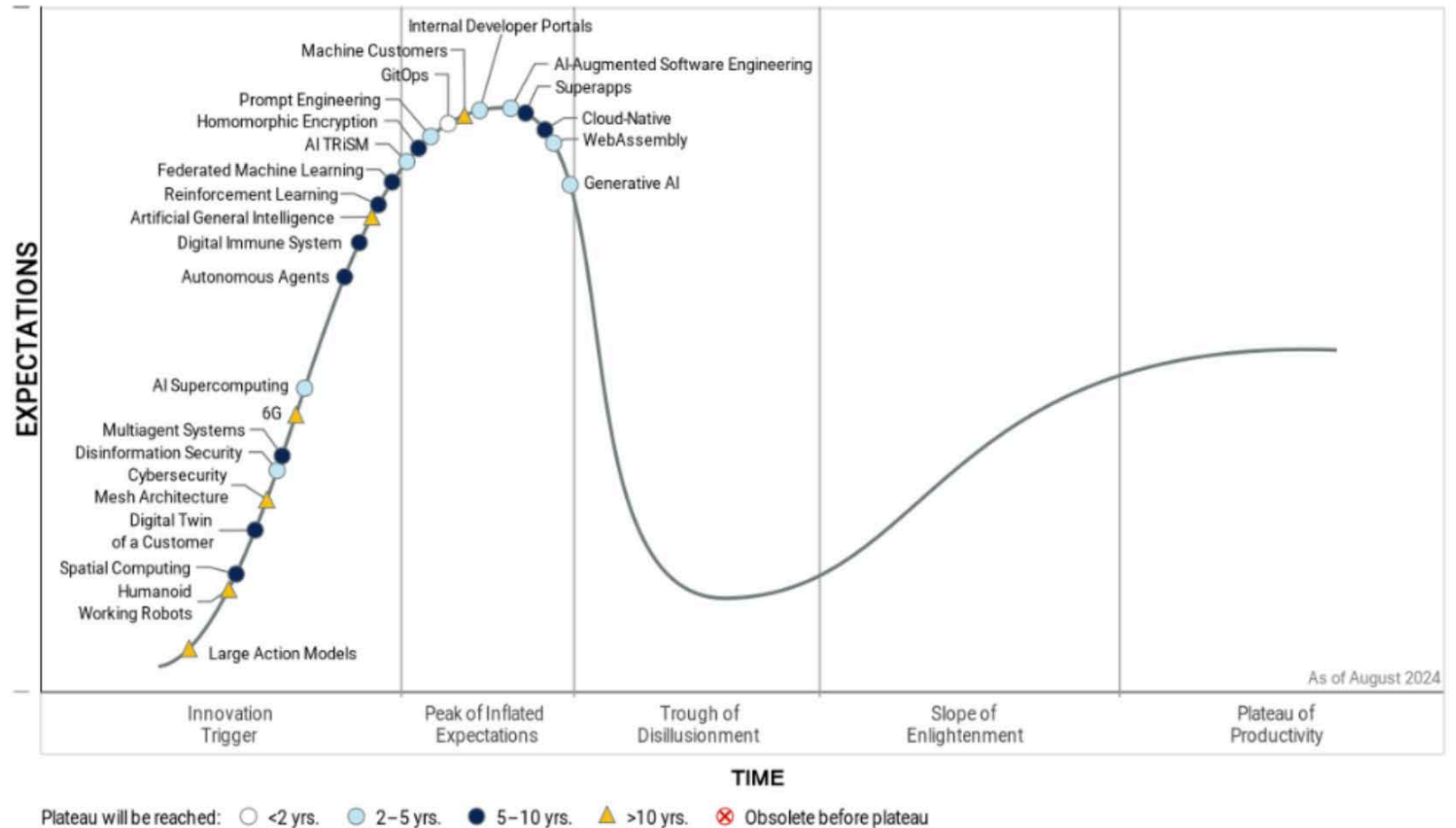| #	Phase	Description
1	Innovation Trigger	Potential technology breakthrough lead to early proof-of-concept stories and media interest trigger significant publicity. No usable products exist and unproven commercial viability
2	Peak of Inflated Expectations	Success stories due to early publicity – often accompanied by scores of failures. Some companies take action; many do not.
3	Trough of Disillusionment	Interest declines due to failure to deliver. Technology producers shake out or fail. Investments continue only if the surviving providers improve their products to the satisfaction of early adopters
4	Slope of Enlightenment	More cases about the value of the technology it widely understood. 2nd and 3rd generation products appear. More enterprises fund pilots; conservative companies remain cautious.
5	Plateau of Productivity	Mainstream adoption take off. More clearly defined criteria for assessing provider viability. The technology's broad market applicability and relevance are clearly paying off.

Gartner Hype Cycle (2024)

On the rise?

At the peak?

Sliding into trough?

Figure 1. Hype Cycle for Emerging Technologies, 2024

Internal Developer Portals
Machine Customers
GitOps
AI-Augmented Software Engineering
Superapps
Prompt Engineering
Homomorphic Encryption
AI TRiSM
Cloud-Native
WebAssembly
Federated Machine Learning
Reinforcement Learning
Artificial General Intelligence
Digital Immune System
Autonomous Agents
Generative AI

AI Supercomputing
6G
Multiagent Systems
Disinformation Security
Cybersecurity
Mesh Architecture
Digital Twin of a Customer
Spatial Computing
Humanoid Working Robots
Large Action Models

EXPECTATIONS

Innovation Trigger | Peak of Inflated Expectations | Trough of Disillusionment | Slope of Enlightenment | Plateau of Productivity

TIME

As of August 2024

Plateau will be reached: ○ <2 yrs. ○ 2–5 yrs. ● 5–10 yrs. ▲ >10 yrs. ⊗ Obsolete before plateau

Gartner.

Source: Gartner (August 2024)

Gartner Hype Cycle (2023)

Hype Cycle for Emerging Technologies, 2023

Dominant Design

Section 2

Product Category

Section 2.1

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Emergence of new product categories: Example

Ford's Quadricycle (1896)

Describes the design (4 wheels)

Emergence of new product categories: Example

All became the product category "automobile" (later "car")

Horseless carriage (1905)

Columbus electric buggy (1905)

Definition: Product Category

- "A product category is all the products offering the same general functionality."

- A socially constructed partition of products that are perceived to be similar and in which firms choose to position their products
  - based roughly on an excerpt from the reading: "Perfect timing? Dominant category, dominant design, and the window of opportunity for firm entry"

http://kwhs.wharton.upenn.edu/glossary/
http://onlinelibrary.wiley.com/doi/10.1002/smj.2225/full

Factors that lead to a "dominant category":

- Technological factors

- Firms attempts to claim beneficial market positions

- Stakeholders making sense of emerging category
    - Suarez et al (2015)

https://onlinelibrary.wiley.com/doi/full/10.1002/smj.2225

Product categories emerging now – Home / Smart Speakers
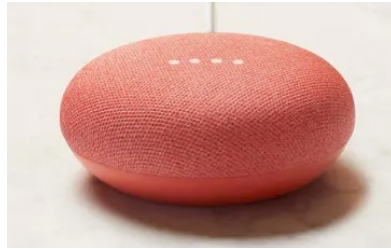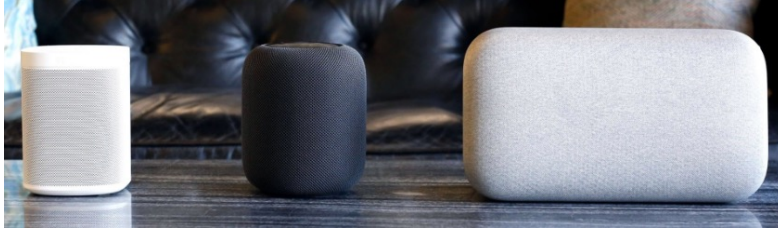
- Samsung Home (Bixby)

- Google Home (ok google)

- Apple HomePod (Siri)

- Amazon Echo (Alexa)

- Working on… Microsoft (Cortana)

https://www.engadget.com/2018/08/09/samsung-galaxy-home-too-little-too-late/

Foldable Phones, a product category ?

Design Dominance & The Technology Cycle
Section 2.2

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The concept of Design Dominance

- Study of the automotive industry in1970s (by Utterback and Abernathy)

- Explanation and prediction of the dynamics of **product and process innovation** in the industry

- A "*Dominant Design*" is the design around which the industry settles.
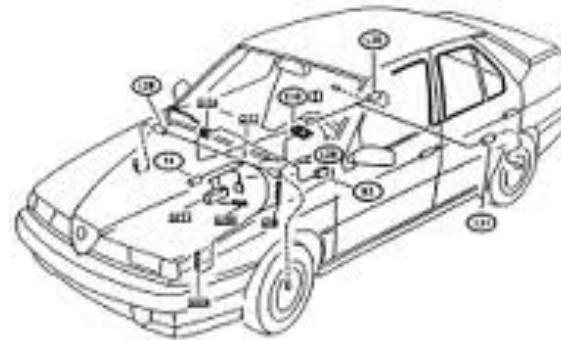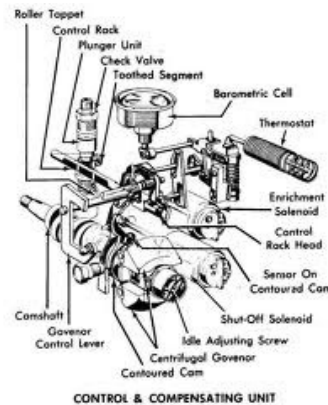
James M. Utterback, Engineering & Technology Mgmt at MIT

https://www.sciencedirect.com/science/article/abs/pii/0305048375900687

The concept of Design Dominance

1. A new product is first introduced, it is usually "made-to-order"
2. If the product attracts significant market share, it forces imitation by competition
3. Competitive products are released
4. There is pressure to reduce costs in components leading to commoditisation of components
5. This requires a "*dominant design*" with components fitting within this design
6. The dominant design may be established by the first company to release a product, a later arrival or by a standards body (e.g., ISO and IEEE)
7. The dominant design becomes a base for the whole industry
8. This design may become a De facto standard or De jure

The Phases of Design Dominance

- Two phases in reaching design dominance (*by Utterback and Abernathy*):

  - **The fluid phase:**
    - Uncertainty about the technology and its market
    - Firms experiment with different product designs
  - **The specific phase:**
    - A stable architecture for the technology
    - Incremental innovations to improve components
    - Process innovations to produce them efficiently and effectively

Dominant Designs in IT

- The concept was traditionally used for industries creating physical products

- Principles also apply to software development:
  - The software industry and software users benefit from using common designs

Examples of Dominant Designs in IT

- IBM PC Architecture

- WIMP (window, icon, menu, pointing device)

- Internet protocol stack (TCP/IP, etc)

- The core web standards (HTML, HTTP, URL)

- LAMP (Linux, Apache, MySQL and Perl/PHP/Python)

- Relational Database Management Systems

- Apple iPhone application architecture

- The Android architecture

- Smart speaker API architecture

Can you give other examples of dominant designs in IT?

Design Dominance and Technology Cycles

Michael L. Tushman, Business Management at Harvard Business School

- – Further developed in the 90s (Anderson and Tushman)
- – Work based on studies of the US minicomputer industry (etc)
- – A new technology may cause a "***technological discontinuity***" in the industry leading to a new cycle
- – Technological discontinuities were *competence-enhancing* or *competence-destroying* for particular companies

Source: Anderson and Tushman (1990)

Design Dominance and Technology Cycles

– Anderson and Tushman found that:

    – The dominant design was never in the same form as the original innovation

    – The dominant design was not the leading edge of the technology

    – The dominant design had the features that met the needs of the majority of the market

    – Example: The IBM PC (and clones) were not the most advanced or the cheapest technology at the time it rose to dominance.
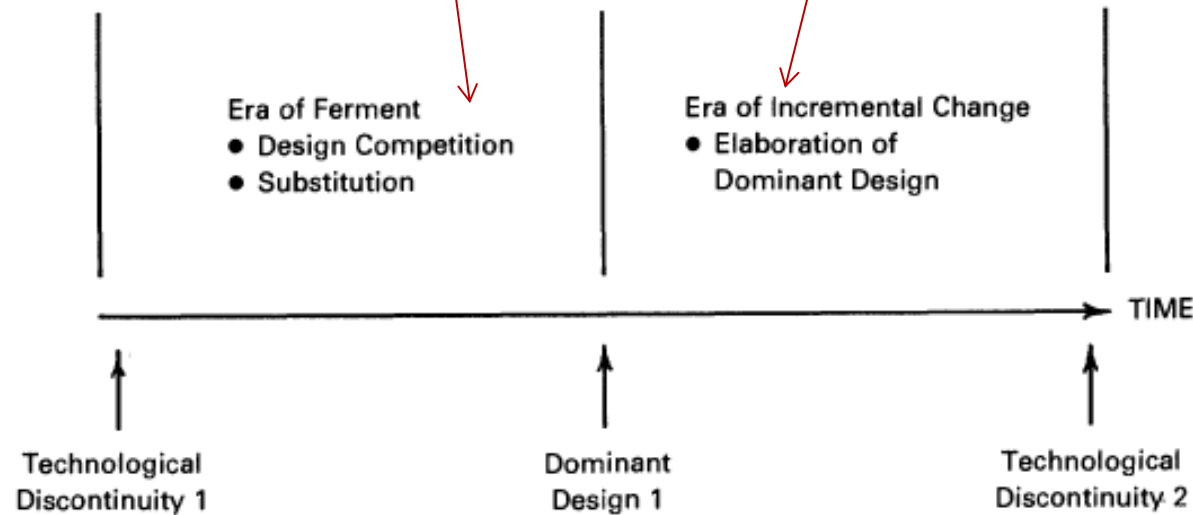
Design Dominance and Technology Cycles

Companies focus on:
• Custom solutions
• Experimentation with different product designs

Companies focus on:
• Increased market penetration
• Improved product functionality (incremental product innovation):
• Improved production efficiency (process innovation)

Era of Ferment
● Design Competition
● Substitution

Era of Incremental Change
● Elaboration of Dominant Design

TIME

Technological Discontinuity 1

Dominant Design 1

Technological Discontinuity 2

The Technology Cycle

Source: Anderson and Tushman (1990)

Design Dominance and Technology Cycles

- "era of incremental change" firms typically focus on:
  - Increased market penetration
    - Segment the market offering different models at different price points
  - Improved product/component functionality (incremental product innovation):
    - New features and increased performance
  - Improved production efficiency (process innovation):
    - Cheaper production by simplification of components or process innovation

- This continues until the next technological discontinuity

Design Dominance and Technology Cycles

- The era of incremental change accounts for most of the technological process

- During the era of incremental change firms often (Anderson and Tushman):
  - stopped investing in learning about alternative designs; and
  - focused on developing competencies related to the dominant design.

- Explain why firms entrenched in a dominant design often don't react to discontinuous technologies:
  - E.g. Microsoft's and AOL's apparent slowness in identifying and acting on the importance of the Internet

# Dominant design and windows of opportunity?

Figure

Caption

Figure 1: Theoretical framework: dominant category and dominant design during the industry life cycle. During the industry life cycle, the number of categories will increase before the number of firms increases. The emergence of the dominant category occurs as the number of categories begins to decrease. This point in time marks the opening of the window of opportunity for entry, whereas the emergence of the dominant design marks the closing of the window of opportunity
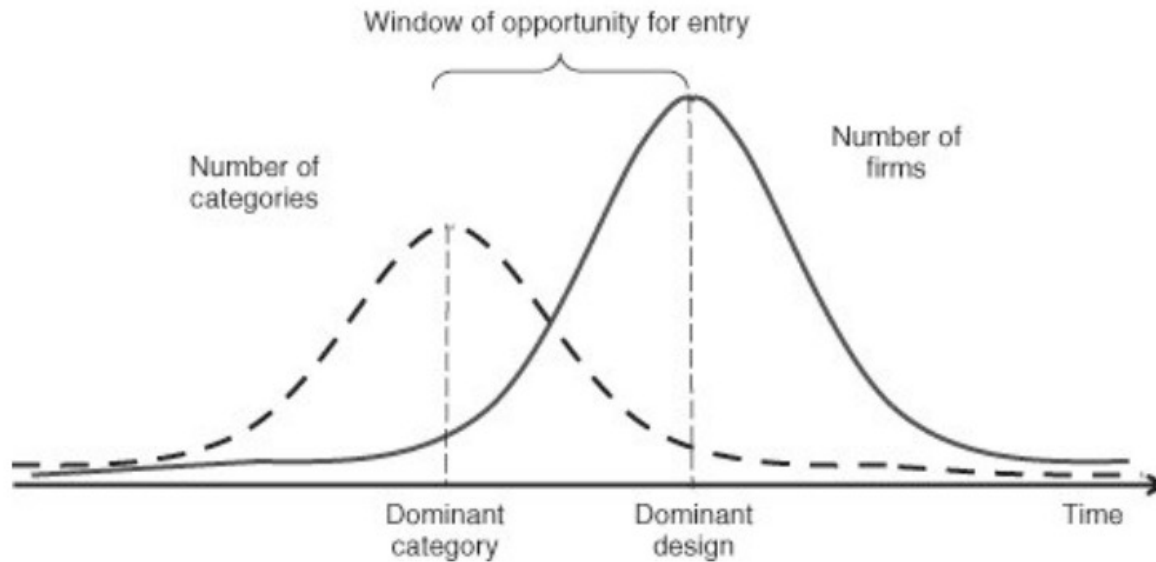
Factors Leading To Dominant Design
Section 2.3

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Why Dominant Designs Are Selected

A. Market forces: Increasing returns to adoption

    – The more a technology is adopted, the more valuable it becomes to the industry:

        1. Learning effects

        2. Network effects

B. Government regulations

    – Sometimes, the government sees the importance of a technology for a nation and regulates a specific dominant design

Why Dominant Designs Are Selected:
1) Learning Effects

– **Learning effects can lead to:**

  – Greater use of the technology

  – Greater knowledge

  – Enables a fast rate of improvement of the technology

  – Company structures and culture are based around the technology

Source: Schilling (2013)
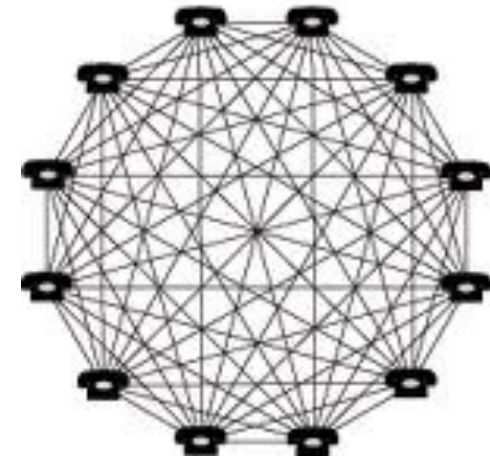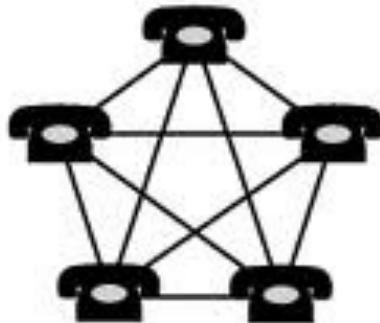
Why Dominant Designs Are Selected:
2) Network effects

- **Network effects**

  - For technologies with network effects, the benefit from using a technology increases with the number of other users

    Examples:

    - Railways → More railway connections = More valuable for transportation.
    - Telephones → A phone is useless alone, but extremely valuable when many people have one.
    - Social Media → More users = More connections = More engaging experience.
    - Messaging Apps → People choose apps where most of their contacts already are.

Why Dominant Designs Are Selected: 2) Network effects

– Popularised in IT by Robert Metcalfe:
  – Co-inventor of Ethernet, Co-founder of 3Com

– Rationale for buying network interface cards:
  – Cost of cards = N
  – Value of cards = N^2

– Known as "Metcalfe's Law"

Types of network effects

- **Direct network effects:**
    - Direct increase in value

- **Indirect network** effects
    - "Increased usage of a product spawns the production of increasingly valuable complementary goods, and this results in an increase in the value of the original product."

- **Two-sided network effects:**
    - Increase in usage by one set of users increases value to another set

- **Local network effects:**
    - Increase in use of local levels leads to increase in value

Source: Arun Sundararajan http://oz.stern.nyu.edu/io/network.html

What is the impact of Network Effects on Technology Adoption?

Why Dominant Designs Are Selected?
The self-reinforcing cycle

– This cycle is deliberately used by companies:

– Companies **deliberately** create dominant designs by making their platforms **indispensable**:

– *"The more applications you have available for a platform, the more people will want to use that platform,*
the more people that want to use that platform, the more software vendors will want to write to that platform."
B.J. Whalen (Microsoft Product Manager)

Do you know any self-reinforcing cycle examples?

The self-reinforcing cycle

Example 1:

Android & iOS → Developers build apps for the largest platforms → More apps attract more users → More users reinforce platform dominance.

Example 2:

PlayStation vs. Xbox → The console with the best exclusive games attracts more users → More users encourage developers to build for that console → The cycle continues.

Why Dominant Designs Are Selected?
B. Government Regulation

- – Strong consumer or economy benefits of having a single dominant design

- – Sometimes government organisations step in and impose a standard

    - **USB-C** is now required by law for electronic devices in the EU, forcing Apple to switch from Lightning to USB-C on iPhones.

    - **5G** network standards are promoted by governments to ensure compatibility and security.

Standards for Dominant Designs

- Sometimes standards are used to maintain a dominant design in an industry
  - a formal standards organisation ("de jure"); or
  - wide public acceptance or market forces ("de facto")

- Standards may be for controlling:
  - Quality (products/services have required characteristics); or
  - Compatibility (products/services can be used with other products/services)
    - Compatibility standards can be:
      - Sponsored
      - Non-sponsored

De jure and De facto standards

De jure standards	
Standards authority	**Example standards**
W3C (World-wide Web Consortium)	HTML, URL, CSS, XML
ISO (International Organisation for Standardisation)	MPEG, CD data format, Office Open XML, computer languages
ANSI (American National Standards Institute)	C
IETF	TCP, IP, HTTP, JSON
Industry consortia	USB, BluRay

De facto standards	
Company	**Example Standards**
Microsoft	Word Doc formats; PowerPoint formats
Adobe	PDF (later became de jure standard), Flash
IBM	PC architecture
Community (with guidelines set by Sun)	Java
Community (with guidelines set by Google)	OpenSocial

Market Entry Strategies
Section 2.4

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First, Second, and Fast Second

- **First mover**
  - Their product may become the dominant design

- **Second mover**
  - Producing '*me-too*' product under that dominant design/standard
  - Less innovative but drives cost/price competing

- **Fast second**
  - Help to create the dominant design when it emerges
  - Established firms with technology to protect try to lead in the new market
  - Timing – has to be ready to move as any first mover

Fast Followers (Second mover)

- A first mover has a 47% chance of failure compared to just 8% for that of a fast follower (long-standing theory)

- Successful disruptor found a model and industry that works, and introduced the notion to the public
    - **Fast followers have a working business model to emulate**

- Example: Uber and Lyft
   - Uber 62 million trips to Lyft's (started as ZimCar in 2007) 13.9 million

Dominant Design Strategy – Fast Second

–   Move fast and arrive first in a new market?

–   But… organizations that end up capturing new markets – the consolidators –are those that time their entry so they appear just when the dominant design is about to emerge.
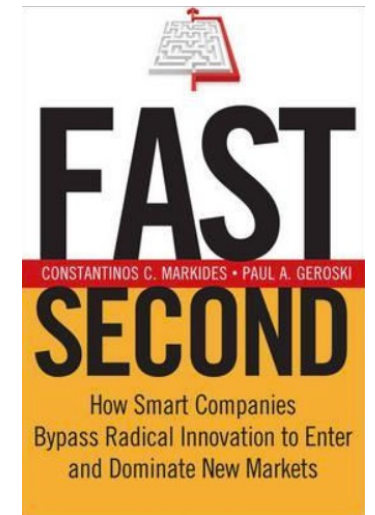
> ➢   *A fast second strategy*

Constantinos C. Markides and
Paul A. Geroski, 'Fast Second',
Harvard Management Update,
HBR, 2008
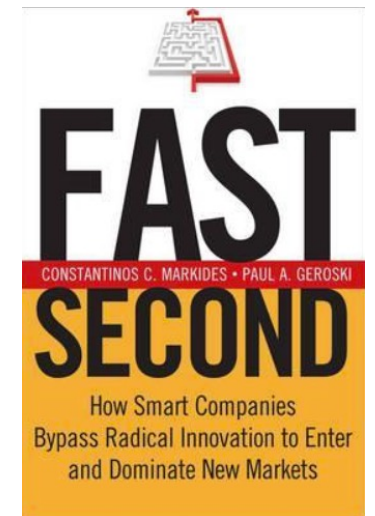
Examples of fast second – Expand this with real examples

– Successful fast second firms

  – **Microsoft**

  – **Canon –** Printer / Camera etc

Constantinos C. Markides and
Paul A. Geroski, 'Fast Second',
Harvard Management Update,
HBR, 2008

Can you think of other fast seconds?

Summary

- Patterns of technology adoption by people, companies and society
  - Companies use knowledge of the diffusion of innovations in planning new technologies/products and knowing when to adopt new products

- There are patterns in the way that new product categories emerge
  - Companies use knowledge of this to influence product categories

- Many industries experience strong pressure to select a single (or few) dominant design(s)

- Factors influence which technology becomes dominant
  - Companies use knowledge of these factors in planning new technologies/products and knowing when to adopt new products