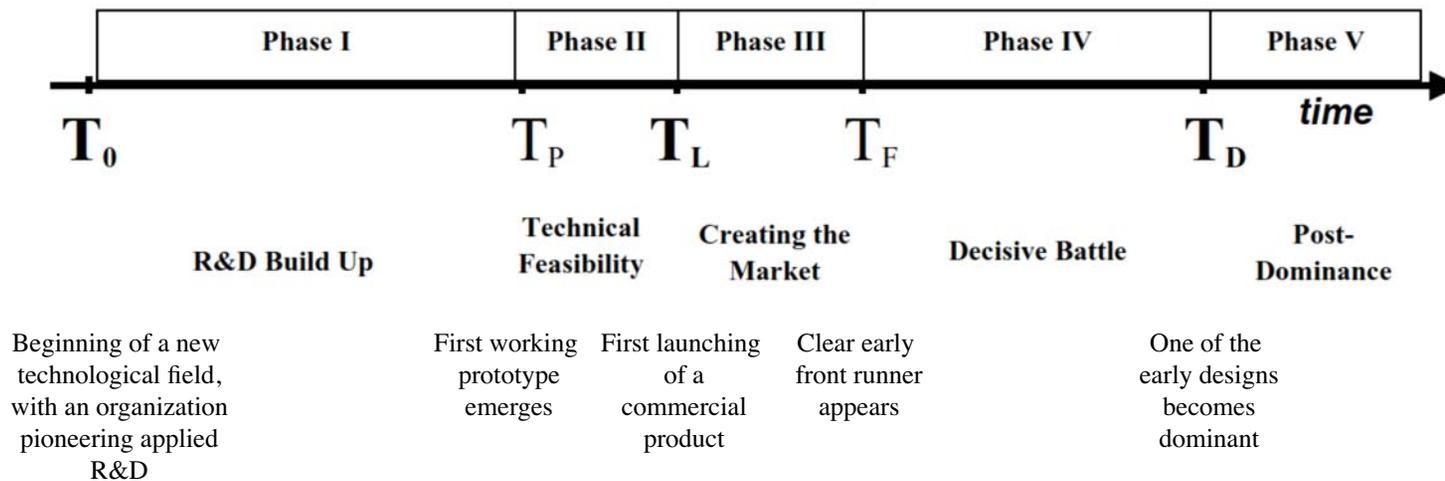# 15.965 Technology & Strategy

Life cycles and transitions
Michael A M Davies

Massachusetts Institute of Technology

There are distinct stages in the battle for technological dominance

Phase I	Phase II	Phase III	Phase IV	Phase V

T_0 T_P T_L T_F T_D *time*

R&D Build Up   Technical Feasibility   Creating the Market   Decisive Battle   Post-Dominance

Beginning of a new technological field, with an organization pioneering applied R&D

First working prototype emerges

First launching of a commercial product

Clear early front runner appears

One of the early designs becomes dominant

Courtesy Elsevier, Inc., http://www.sciencedirect.com. Used with permission.

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These phenomena often result in characteristic {product | industry} 'life-cycle' (YMMV)

	Early ferment	Dominant design emerges	Incremental innovation	Maturity	Eclipse or renewal
Demand Opportunity	Lead users, early adopters - high payoff, low switching costs	Early mainstream - usability, cost more important	Mainstream customers - soft factors, aesthetics	Saturation, segmentation, customization	Find *new needs* or *new customers*
Business Ecosystem	Many entrants - diverse business models	Decisive battles for leadership	Intensifying competition, early consolidation	Fierce competition, consolidation around majors and minors	
Technological Infrastructure	Make it work - innovate on *performance*, diverse integrative designs	Select optimal architecture, drive down *costs*, focus on *ease of use*	Provide broader offer, rationalize *portfolio*, build complementary *assets*	Develop *broad portfolio*, build *platforms*	Search for *new options*

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Dominant design

- After significant technological innovation and subsequent era of ferment, form factor and architecture that becomes accepted market standard
- Dominant designs may not be better than alternatives, nor innovative
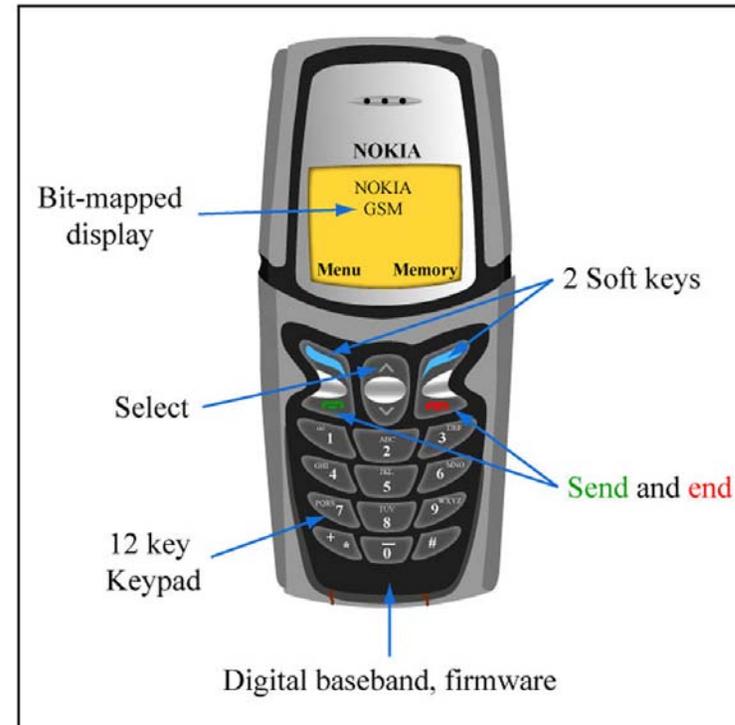- They have benchmark features to which subsequent designs are compared

Image by MIT OpenCourseWare.

New dominant designs?

Image by Dan_H on Flickr [http://www.flickr.com/photos/dan_h/667441709]

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Or is it the Palm Pre?

- Ed Colligan: "We've learned and struggled for a few years here figuring out how to make a decent phone. PC guys are not going to just figure this out. They're not going to just walk in." (2006)

- Roger McNamee: "You know the beautiful thing: June 29, 2009, is the two- year anniversary of the first shipment of the iPhone. **Not one of those people will still be using an iPhone a month later**." (5 March 2009)

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Some clarifications from Palm itself, on performance…

Pleas read some of Palm's recitation available at:
http://www.osnews.com/story/21113/palm_Whips_Mcnamee_Retracts_investor_s_statements

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The relative speed with which technology and demand co-evolve results in different scenarios

Image removed due to copyright restrictions.

Fernando Suarez and Gianvito Lanzolla, "The Half-Truth of First-Mover Advantage",
Harvard Business Review, April 2005, pages 121-127

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…and determines how likely a business is to be able to achieve first-mover advantage

Image removed due to copyright restrictions.

Fernando Suarez and Gianvito Lanzolla, "The Half-Truth of First-Mover Advantage", Harvard Business Review, April 2005, pages 121-127

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Technological innovation and the diffusion of innovations cause transitions

- *Incremental* innovation involves relatively minor changes
- *Radical* innovation is based on different engineering and scientific principles

Performance

Incremental innovation

Incremental innovation

Dominant design

Ferment

Radical innovation

Ferment

Time
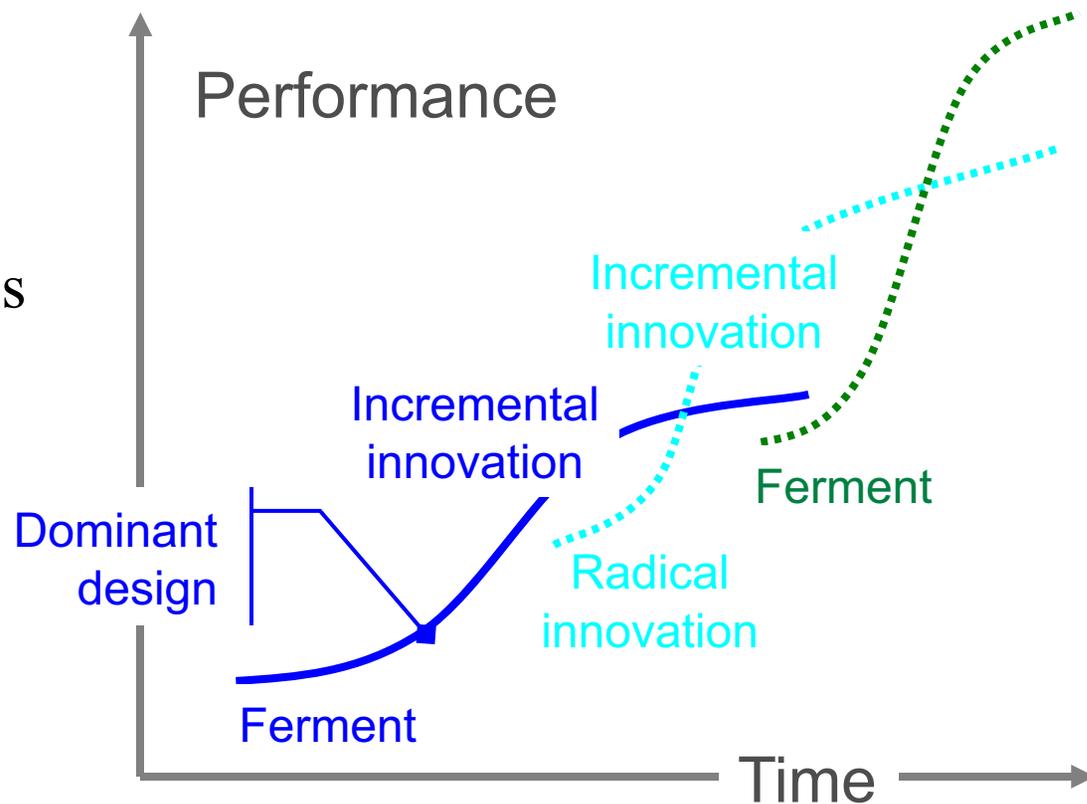
Incremental and *radical* innovations have very different competitive consequences

Incremental innovation	Radical innovation
• Introduces relatively minor changes	• Based on a different set of engineering principles
• Happens once dominant design has been established	• May open up whole new markets and potential applications
• Typically drives rapid performance improvement	• Often creates great difficulties for incumbent firms
• Exploits the potential of the established design	• **Can be basis for successful entry by insurgents**
• **Typically reinforces position of incumbents**	

Explanations for why transitions are so challenging have been driven by observing anomalies

Theory is a statement of what causes what, and why.

Theory

Predict

Confirm

Deductive process

Categorization

Inductive process

The lenses of other disciplines

Observe, describe & measure the phenomena

Anomaly

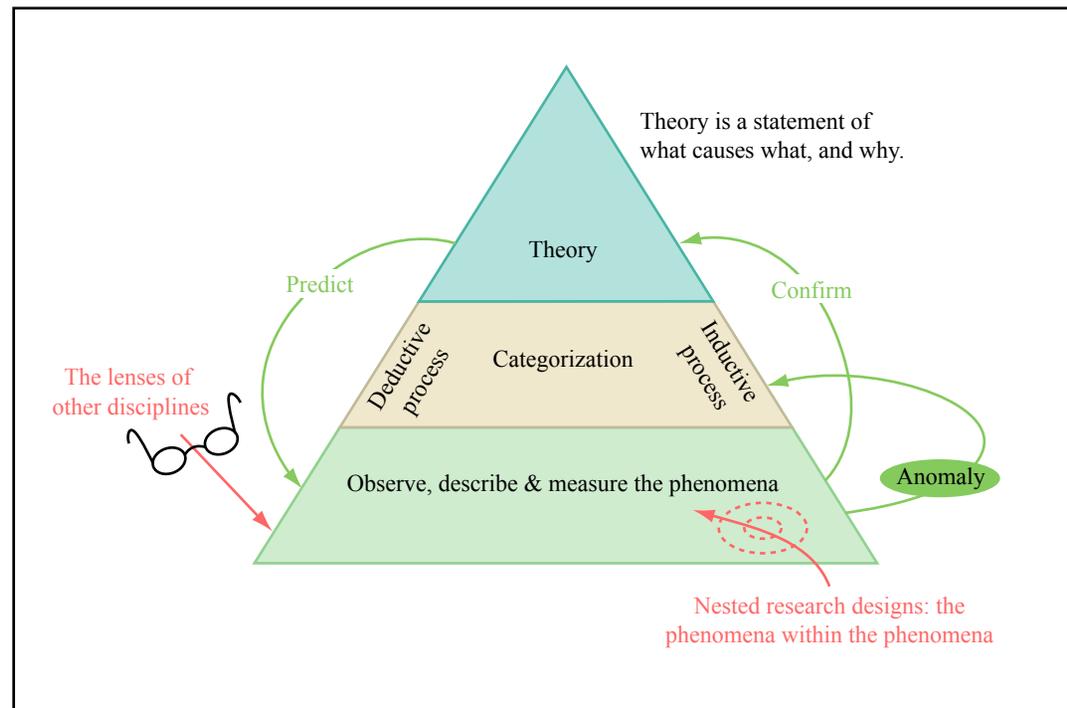Nested research designs: the phenomena within the phenomena

Image by MIT OpenCourseWare.

Clayton Christensen and Michael Raynor,
"Why Hard-Nosed Executives Should Care About Management Theory",
Harvard Business Review, September 2003, pages 66-74

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For example, sometimes, "…apparently modest changes…" have dramatic consequences

Xerox and Canon in small copiers

- Pioneers plain paper copiers
- In 1970's competitors win share with much smaller, more reliable copiers
- Little new scientific or engineering knowledge
- But Xerox takes ~8 years to launch competitive product
- …and it loses 50% of its market share

Sony and RCA in portable radios

- Mid-1950's RCA develops prototype portable radio
- Sony- small new insurgent - uses transistorized radio to enter US market
- Sony's radios produced with technology licensed from RCA
- But RCA doomed as a follower, can't match Sony

Rebecca Henderson and Kim Clark, "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms", Administrative Science Quarterly, March 1990, pages 9-30

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Two different sorts of knowledge: component or modular; architectural or integrative
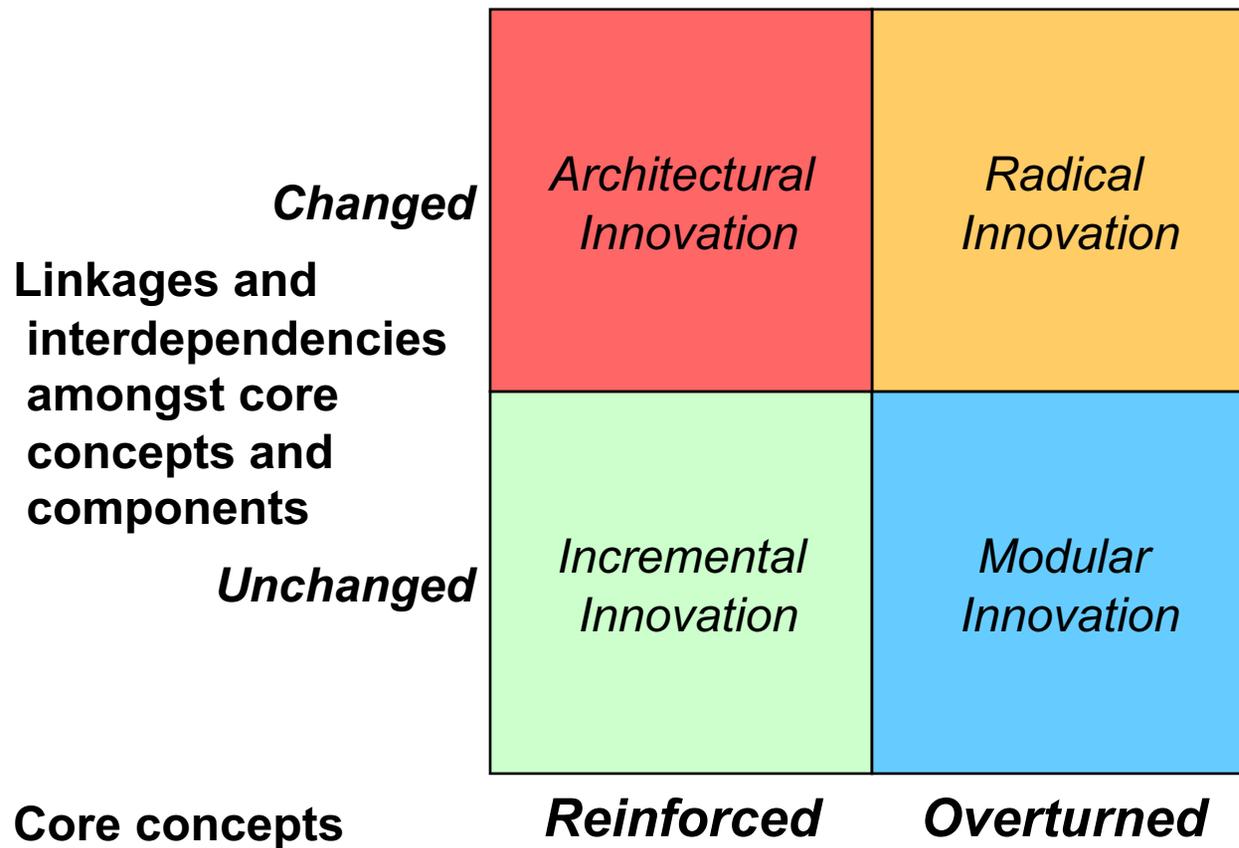
Component

- Knowledge about each of the core design concepts
- How they are implemented in a particular component within a product
- Specialized and focused, can be mastered by an individual or a small team
- Constant focus once dominant design established
- Radical change obvious

Architectural

- Knowledge about ways in which components link together into coherent whole and are interdependent
- Tends to become embedded as tacit knowledge
- Communication channels, information filters and problem-solving strategies
- Shift may not be apparent

Rebecca Henderson and Kim Clark, "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms", Administrative Science Quarterly, March 1990, pages 9-30

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A framework for thinking about different types of innovation and the resulting transitions

	Reinforced	**Overturned**
Changed	*Architectural Innovation*	*Radical Innovation*
Unchanged	*Incremental Innovation*	*Modular Innovation*

Linkages and interdependencies amongst core concepts and components

Core concepts

Rebecca Henderson and Kim Clark, "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms", Administrative Science Quarterly, March 1990, pages 9-30

Architectural innovation and the consequences of transitions in semiconductor capital equipment

Generation

Firm	1st Contact	2nd Proximity	3rd Scanner	4th Step and Repeat (1)	5th Step and Repeat (2)
Nikon					70
GCA				55	12
Perkin-Elmer			78	10	<1
Canon		67	21	9	
Kasper	17	8			
Cobilt	44				

Rebecca Henderson and Kim Clark, "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms", Administrative Science Quarterly, March 1990, pages 9-30

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Difficult transitions also happen when technological innovation outstrips the demand opportunity

Image removed due to copyright restrictions.

Clayton Christensen, Michael Raynor and Matt Verlinden "Skate to Where the Money Will Be", Harvard Business Review, November 2001, pages 72-81

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(Potentially) disruptive technologies must have two key characteristics

- Products and services that embody these technologies **in their early stages** have **attributes** that make them **unattractive to incumbents' current mainstream customers**, and typically appeal only to small and emerging markets or segments, and offer inferior returns

BUT

- These technologies have the **potential for rapid innovation** along trajectories that will **in future enable products** or services that will then become **attractive to incumbents' mainstream** customers, allowing insurgents to later invade established markets and displace the incumbent

Three things all then need to happen for these technologies to threaten incumbents

Initial insurgent investment + Innovation trajectory + Incumbent indifference

- Even though products that embody these technologies are unattractive to incumbents' current mainstream customers at the outset, insurgents perceive sufficient demand opportunity to fuel investment and innovation

- The innovation trajectory for these technologies evolves in the right direction and fast enough to meet the evolving requirements of the incumbents' current mainstream customers

- The demand opportunity represented by incumbents' current mainstream customers is evolving along a different trajectory than can best continue to be met using incumbents' sustaining technologies

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Disruptive innovations in disk drives

- An alternative explanation for failure
  - could have mastered the *architectural transition*
  - but novel technologies did not meet needs of current *customers*
- Response to transition depends on both *technical innovation* **and** on the perceived *demand opportunity*, business model and capabilities

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Each of these generations involved significant shifts in the *direction* of the innovation trajectory

	Generation				
	1st	**2nd**	**3rd**	**4th**	**5th**
	14"	8"	5.25"	3.5"	2.5"
Demand opportunity	Mainframe	Mini-computers	Desktop computers	Portable computers	iPods
Leader(s)	CDC	Shugart	Seagate	Conner Quantum	
New attributes		Internal power supplies Smaller	Higher density Lower unit cost	Rugged Lightweight Low-power	Tiny

Clayton Christensen, "Exploring the Limits of the Technology S-Curve - Part I: Architectural Technologies", Production and Operations Management, Fall 1992, pages 358-366

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Although *disruptive technologies* require special conditions, they can be extremely powerful

- Disk drives
- Mainframes, mini-computers and personal computers
- Digital cellular, versus analog cellular
  - worse coverage and voice quality
  - larger and more costly cellphones
- IP and packet switching, versus TDM and ATM
  - difficult to manage
  - no QoS

Even when incumbents anticipate disruption and respond, *cognitive* limitations may doom them

- Polaroid was the leader in instant photography
  - 23% pa sales, 17% profit growth late '40s to late '70s
- A technology-driven company
  - belief that long-term, large-scale research enables great products, great products create their own market
  - endogeneous demand, little need for or value in conventional market research
- Believed in consumables
  - *"What's the business model? It's the razor/blade … so we make money with the film"*
  - *"… in the photographic business, all the money is in the software [film], none of it is in the hardware…"*

Mary Tripsas and Giovannit Gavetti "Capabilities, Cognition and Inertia: Evidence from Digital Imaging", Strategic Management Journal, 2000, pages 1147-1161

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Polaroid is initially successful at developing technologies, but fails at product development

- '81 digital imaging group
- '86 microelectronics lab
- *"..orientation was 'technical challenge' – we can do it."*
- By 1989 >40% of R&D spend on digital imaging
- Major technological breakthroughs
- By '96, 66% of R&D
- '93 sells microelectronics lab to MIT

- BUT few successful new products
  - Helios
  - Printer in the Field
  - PDC-2000 not 'til '96
- As of 1997, >90% of revenue from established products
- Digital imaging has lost $120-130 million

# Response to transition – whether your survive or thrive – ultimately depends on four key factors

Demand opportunity -
who your customers are and
what they want

- -

*Business model and
business ecosystem* -
your chosen niche and target
customers, its business model
and hence how you make
money

- -

*Technological infrastructure
and innovation* –
explicit and tacit component
and architectural knowledge
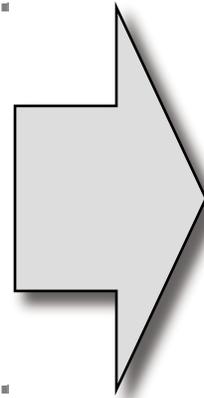
Your *mental models*
- beliefs about the
future, about how to
make money,
reflected in your
communication
channels,
information filters
and search and
problem-solving
strategies

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15.965 Technology Strategy for System Design and Management

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