
Frameworks for Thinking about Modularity, Industry Architecture, and Evolution

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Sloan Industry Studies Conference—2007
April 27, 2007
Boston, MA

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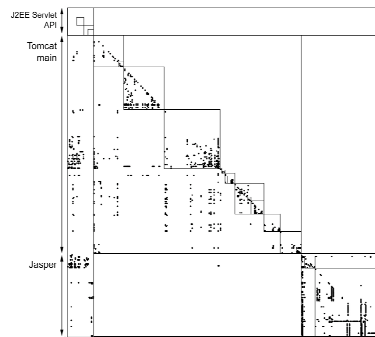
What is modularity?

- ◆ A *particular pattern* of dependencies among elements of a system
- ◆ Design elements ==> design parameters
- ◆ Production elements ==> production tasks

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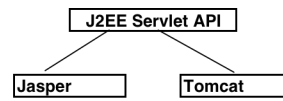
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Three Equivalent Frameworks for Representing Modular Dependencies

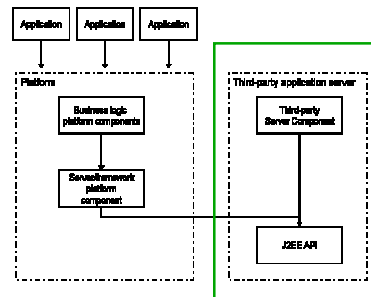


Design Structure Matrix
from LaMantia et.al.
2007

Platform



Design Hierarchy



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What is architecture?

- ◆ *The pattern of dependencies among elements of a system*
- ◆ *Modular, integral, sequential, hybrid architectures...*
- ◆ *Of design and production*
- ◆ *= Industry architecture*

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Why should industry scholars care about modularity and industry architecture?

Because...

Architectures influence industry change, evolution, dynamics

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The standard story of innovation and industry evolution envisions

a one-layer, integral architecture with unchanging product and value-chain boundaries

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Stylized facts of “industry” evolution (Klepper, AER, 1996)

1. When an industry first forms, numerous firms enter, but the number of entrants eventually declines (“era of ferment”)
2. Number of producers grows to a peak and then declines (after emergence of “dominant design”)
3. Eventually, market shares stabilize
4. Diversity of products rises with the number of producers, then falls
5. Over time, producers devote more resources to process relative to product innovation
6. Most product innovations come from recent entrants

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Less formally... “industry life cycle”

- ◆ First, there is competition in product designs
- ◆ Then a “dominant design” emerges
- ◆ After DD, competition switches from product design to process improvement
 - *(Note: Product and process are inseparable! And markets are exogenous.)*
- ◆ There is a shakeout
- ◆ Other things equal, the first to introduce the dominant design dominates the industry
- ◆ **Repeat as necessary to explain real events!**

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Empirical evidence

- ◆ Lots!
- ◆ Mostly from industries with *stable internal and external boundaries*
- ◆ Mostly from before *the 1980s, 1990s, 2000s*
- ◆ *which brought*—
 - IT-enabled organizational design technologies
 - High-powered financial incentives for managers
 - Mergers & Acquisitions markets making boundary changes easy

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So now, what about...

- ◆ The business service industry?
- ◆ The bike drive train *industries*?
- ◆ The computer industry?
- ◆ The auto industry?
- ◆ The semiconductor industry?
- ◆ The fabric/fashion industry?

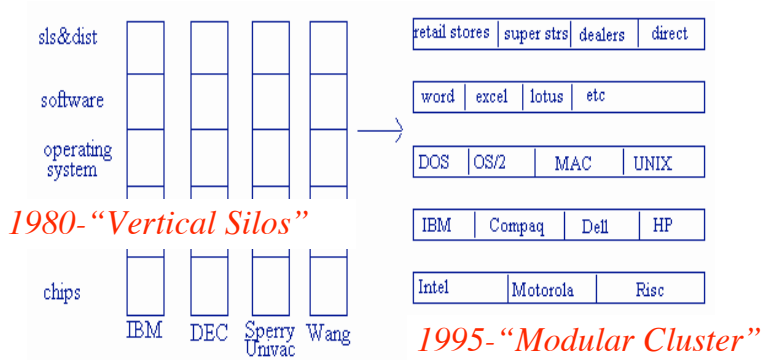
These are all exceptions to the standard story!

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The Computer Industry

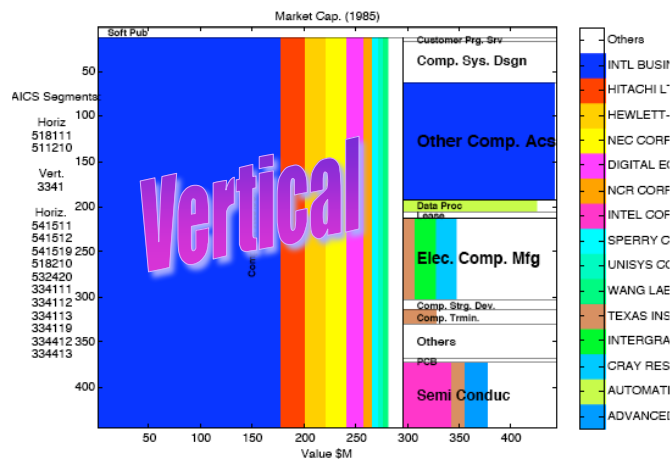
- ◆ Andy Grove's representation of an industry changing its structure



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The Computer Industry in 1985



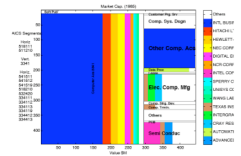
"Layermaps" are joint work with Michael Jacobides and Reza Dizaji

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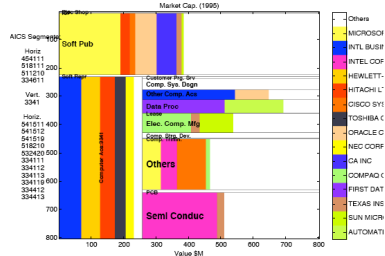
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The architecture did change—

1985



1995



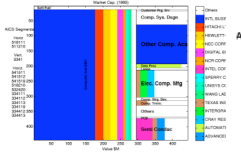
Verticals are giving up ground...

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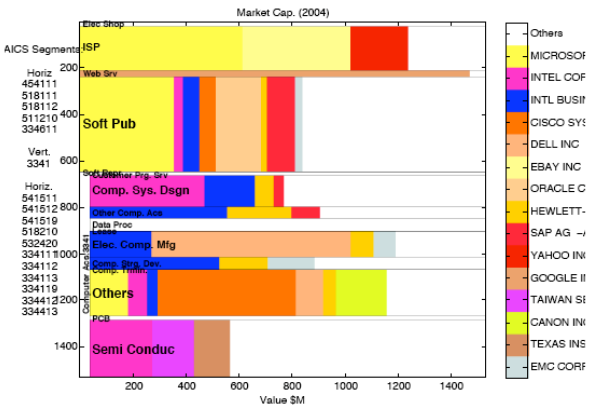
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And then changed some more!

1985



2004

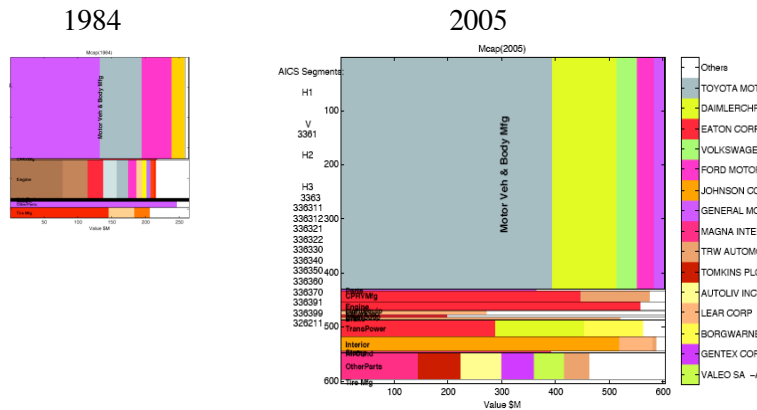


Verticals have disappeared

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Same time period... the auto industry stayed very vertical



Why the difference? We don't know!

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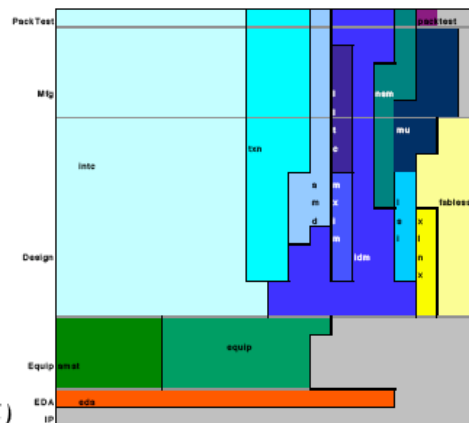
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The semiconductor industry: IDMs vs Fabless-Foundry

Strojwas (2005)
Top 10 Firms:
1994

Fabless firms
 beginning to
 make inroads

Many predict
 impending
 shift to
 horizontal
 structure



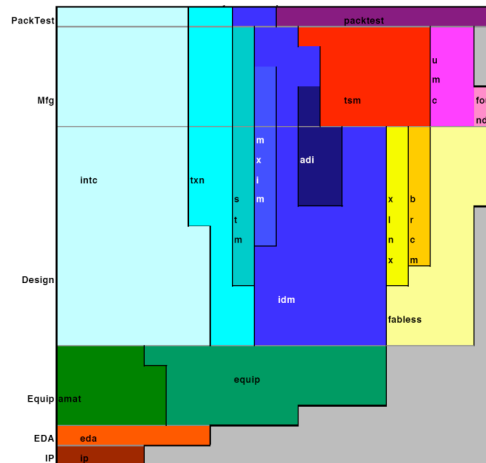
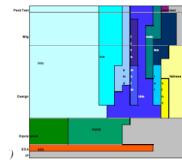
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But shift did not happen —

Strojwas (2005)
Top 10 Firms:
1994 and 2004

Verticals are
holding their
own!



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Summary of the *New Evidence...*

- ◆ **Horizontals replaced verticals**
 - Computer industry
 - Mortgage banking (Jacobides, 2005)
- ◆ **Verticals replaced horizontals**
 - Bike drive trains (Fixson and Park, 2007)
 - Classic Chandlerian industries
- ◆ **Verticals are holding their own**
 - Autos (MacDuffie, 2006)
 - Semiconductors (Strojwas, 2006)
- ◆ **Being fought right now**
 - Business service outsourcing (Sako and Helper, 2007)
 - Telecomm = Battle of consultants

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A theory of industry evolution via changing architectures

- ◆ Firms of different vertical scope compete in a set of related product markets (*Note: the product markets are endogenous to the firms' architectures—Evidence presented in this panel*)
- ◆ Focused firms must define and encapsulate modules
 - May need to create markets *and non-threatening complementors*
 - Pay higher transaction costs, both mundane and opportunistic
 - More vulnerable to holdup by complementors
 - Create modular architectures and innovate within them
- ◆ Vertically integrated firms *can choose* to be more or less modular internally (Jacobides and Billinger, 2007)
 - Suffer from organizational rigidities, loss of high-powered incentives/accountability, lower ROIC
 - Do not need modular architectures to innovate

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Industry evolution via changing architecture (cont)

- ◆ Integrated firms compete against vertically disintegrated combos (eg, fables-foundry combo, the bike drive train combo)
- ◆ Focused firms compete against integrated firms *and their own complementors*
- ◆ Industry architecture moves toward *richer design spaces*
- ◆ Richness of design spaces is a function of architectural knowledge...

But that's a story for another day!

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Thank you!