eClockspeed-based Principles for Supply Chain Design*

Professor Charles Fine
Massachusetts Institute of Technology
Sloan School of Management
Cambridge, Massachusetts 02142
January 2001
charley@mit.edu
http://www.clockspeed.com
Tel: 1-617-253-3632, Fax: 1-617-258-7579

eClockspeed-based Principles for Value Chain Design

1. Fruit Flies & Temporary Advantage (defs, Intel, dependence, Helix, acceleration)

2. Supply Chain Design & 3-DCE (architectures, dependencies, core comps, make/buy, mapping, decision process)

3. eBusiness Phenomena: Business Model Innovation (e-tailing, B2B=mkts+e2e+NPD, CPM, free info flow)
Value Chain Design in a Fast-Clockspeed World:
Study the Industry Fruitflies

Evolution in the natural world:

FRUITFLIES evolve faster than MAMMALS
   evolve faster than REPTILES

THE KEY TOOL:
Cross-SPECIES Benchmarking of Dynamic Forces

Evolution in the industrial world:

INFOTAINMENT evolves faster than MICROCHIPS evolve faster than AUTOS evolve faster than AIRCRAFT evolve faster than MINERAL EXTRACTION

THE KEY TOOL:
Cross-INDUSTRY Benchmarking of Dynamic Forces
INDUSTRY CLOCKSPERED IS A COMPOSITE: OF PRODUCT, PROCESS, AND ORGANIZATIONAL CLOCKSPEREDS

Automobile INDUSTRY CLOCKSPERED

THE Automobile product technology

THE Automobile production process

THE Automobile manufacturing company organization

process technology
Automobile CLOCKSPED IS A MIX OF ENGINE, BODY & ELECTRONICS

ISSUE: MOST AUTO FIRMS OPERATE AT ENGINE OR BODY CLOCKSPEDS; IN THE FUTURE THEY WILL NEED TO RUN AT ELECTRONICS CLOCKSPED.
1980: IBM designs a product, a process, & a supply chair

The Outcome:
A phenomenally successful product design
A disastrous supply chain design (for IBM)
LESSONS FROM A FRUIT FLY: THE PERSONAL COMPUTER

1. BEWARE OF \textit{INTEL INSIDE} (Regardless of your industry)

2. MAKE/BUY IS \textbf{NOT} ABOUT WHETHER IT IS TWO CENTS CHEAPER TO OUTSOURCE

3. SUPPLY CHAIN DESIGN CAN DETERMINE THE FATE OF \textbf{COMPANIES AND INDUSTRIES}, AND OF PROFIT AND POWER

4. THE LOCUS OF SUPPLY CHAIN CONTROL CAN SHIFT IN \textbf{UNPREDICTABLE WAYS}
Vertical Industry Structure with *Integral* Product Architecture

Computer Industry Structure, 1975-85

- IBM
  - All Products
- DEC
  - All Products
- BUNCH
  - All Products

(A. Grove, Intel; and Farrell, Hunter & Saloner, Stanford)
Horizontal Industry Structure with Modular Product Architecture

Computer Industry Structure, 1985-95

<table>
<thead>
<tr>
<th>Microprocessors</th>
<th>Intel</th>
<th>Moto</th>
<th>AMD</th>
<th>etc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Systems</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peripherals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Applications Software</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network Services</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assembled Hardware</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(A. Grove, Intel; and Farrell, Hunter & Saloner, Stanford)
THE DYNAMICS OF PRODUCT ARCHITECTURE AND INDUSTRY STRUCTURE: 
THE DOUBLEHELIX

Fine & Whitney, "Is the Make/Buy Decision Process a Core Competence?"
THE DOUBLE HELIX
IN OTHER INDUSTRIES

• TELECOMMUNICATIONS--
  – “MA BELL” was Vertical /Integral
  – BABY BELLS & LONG LINES & CELLULAR are Horizontal/Modular
  – Today’s AT&T going back to Vertical /Integral

• AUTOMOTIVE--
  – Detroit in the 1890’s was Horizontal/Modular
  – Ford & GM in the mid 1900’s were Vertical /Integral
  – Today’s Auto Industry is going back to Horizontal/Modular

• TELEVISION--
  – RCA was Vertical /Integral
  – 1970’S THROUGH 1990’S were Horizontal/Modular
  – Today’s media giants are going back to Vertical /Integral

• BICYCLES--
  – Safety Bikes to 1890’s boom to Schwinn to Shimano Inside
Controlling the Chain Through Distribution: The End of *P&G Inside*?

Controlling the Channel Through Closeness to Customers: consumer research, pricing, promotion, product development

Diagram:

- Customers
- Retailer
- Retailer
- Retailer
- P&G
Controlling the Channel Through Closeness to Customers: Chain Proximity

Controlling the Chain Through Distribution: Beware of Walmart Outside
Battle for Channel Control - Proprietary Systems v. Closeness to Customers

Customers

Compaq

Dell

Gateway

AMD

Nexgen

Intel
Volatility Amplification in “The Bullwhip Effect” and Clockspeed Amplification in “The Speedup Effect”

Inventories & Orders fluctuate more as you look upstream, tough on suppliers, but

Clockspeeds accelerate as you head downstream, closer to the final customer
Media Supply Chains: An Industry at *Lightspeed*

Customers: Telephone, Personal Computer, Television, VCR, Pager

The box: Telephone, Personal Computer, Television, VCR, Pager

The Pipe: Phone network: -copper, -fiber optics, Airwaves: -broadcast TV, -cellular tel, -satellite/microwave, Cable Networks, Retail Outlets for CD’s, tapes, print: -Blockbuster, -Seven-Eleven

ALL COMPETITIVE ADVANTAGE IS TEMPORARY

*Ford* in the late 1910’s and early 1920’s

*GM* in the 1950’s and 1960’s

*IBM* in the 1970’s

*Microsoft* in the 1990’s

The *Greeks*, The *Romans*,

The *Ottomans*, The *Huns*

The *Yankees*, The *Cowboys*,

The *Celtics*, The *Canadiens*

*The faster the clockspeed, the shorter the reign*
eClockspeed-based Principles for Value Chain Design

1. Fruit Flies & Temporary Advantage
   (defs, Intel, dependence, Helix, acceleration)

2. Supply Chain Design & 3-DCE
   (architectures, dependencies, core comps, make/buy, mapping, decision process)

   (e-tailing, B2B=mkts+e2e+NPD, CPM, free info flow,
SUPPLY CHAIN DESIGN:
Three Components

1. Insourcing/OutSourcing
(The Make/Buy or Vertical Integration Decision)

2. Supplier Selection
(Choice of suppliers and partners for the chain)

3. The Contractual Relationship
(Arm’s length, joint venture, long-term contract, strategic alliance, equity participation, etc.)
IMPLEMENTATION OF SUPPLY CHAIN DESIGN: EMBED IT IN 3-D CONCURRENT ENGINEERING

Recipe, Unit Process

Performance Specifications

Technology, & Process Planning

Details, Strategy

Time, Space, Availability

Manufacturing System, Make/Buy processes

Product Architecture, Make/Buy components

Supplies Chain
Integral product architectures feature close coupling among the elements
- Elements perform many functions
- Elements are in close spacial proximity
- Elements are tightly synchronized
  - Ex: jet engine, airplane wing, microprocessor

Modular product architectures feature separation among the elements
- Elements are interchangeable
- Elements are individually upgradeable
- Element interfaces are standardized
- System failures can be localized
  - Ex: stereo system, desktop PC, bicycle
Integral supply-chain architecture features close proximity among its elements
- Proximity metrics: Geographic, Organizational Cultural, Electronic
  - Example: Toyota city
  - Example: Ma Bell (AT&T in New Jersey)
  - Example: IBM mainframes & Hudson River Valley

Modular supply-chain architecture features multiple, interchangeable supplier and standard interfaces
- Example: Garment industry
- Example: PC industry
- Example: General Motors’ global sourcing
- Example: Telephones and telephone service
# Designing Architectures for Products & Supply Chains: The Need for Alignment

## Supply Chain Architecture (Geog., Organ., Cultural, Elec.)

## Integral Modular Product Architecture

<table>
<thead>
<tr>
<th>Integral</th>
<th>Modular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jet engines</td>
<td>Polaroid</td>
</tr>
<tr>
<td>Microprocessors</td>
<td>Nortel</td>
</tr>
<tr>
<td>Mercedes vehicles</td>
<td></td>
</tr>
<tr>
<td>Automotive Supplier Parks</td>
<td>Personal Computers</td>
</tr>
<tr>
<td></td>
<td>Bicycles</td>
</tr>
<tr>
<td></td>
<td>Chrysler Vehicles</td>
</tr>
<tr>
<td></td>
<td>Cisco</td>
</tr>
</tbody>
</table>
DESIGNING ARCHITECTURES FOR PRODUCTS & SUPPLY CHAINS: MODULARITY VS. OPENNESS

ARCHITECTURAL PROPRIETARINESS

ARCHITECTURAL STRUCTURE

INTEGRAL

MODULAR

CLOSED

Pentium Chip
Mercedes Vehicles
SAP ERP

OPEN

Linux

IBM Mainframes
Microsoft Windows
Chrysler Vehicles

Palm Pilot
software & accessories
Phones & service
Web-based ERP
In/ Outsourcing: Sowing the Seeds of Competence Development to develop dependence for knowledge or dependence for capacity

**Dependence**
- Amount of Work Outsourced
  - knowledge +/-or supply

**Independence**
- Amount of Work Done In-house
  - knowledge +/-or supply

- Supplier Capability
- Supplier Learning
- Internal Capability
- Internal Learning

*MIT 2000 clockspeed.com*
Dynamics between New Projects and Core Capability Development

CORE CAPABILITIES

NEW PROJECTS
(New products, new processes, new suppliers)

Leonard-Barton, *Wellsprings of Knowledge*
Technology Dynamics in the Aircraft Industry: LEARNING FROM THE DINOSAURS

Japanese Industry Autonomy

Boeing outsources to Japan (*Mitsubishi Inside?*)

Japanese appeal as subcontractors

U.S. firms’ appeal as subcontractors

Japanese industry size & capability

U.S. industry size & capability

*MIT 2000
clockspeed.com
Strategic Make/Buy Decisions: Assess Critical Knowledge & Product Architecture

<table>
<thead>
<tr>
<th>Item is Modular</th>
<th>Dependent for Knowledge &amp; Capacity</th>
<th>Dependent for Capacity Only</th>
<th>Independent for Knowledge &amp; Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Potential Outsourcing Trap</td>
<td>Best Outsourcing Opportunity</td>
<td>Overkill in Vertical Integration</td>
<td></td>
</tr>
<tr>
<td>Worst Outsourcing Situation</td>
<td>Can Live with Outsourcing</td>
<td>Best Insourcing Situation</td>
<td></td>
</tr>
</tbody>
</table>

Adapted from Fine & Whitney, “Is the Make/Buy Decision Process a Core Competence?”
Strategic Make/Buy Decisions:
Also consider Clockspeed & Supply Base Capability

<table>
<thead>
<tr>
<th>DEPENDENT FOR KNOWLEDGE &amp; CAPACITY</th>
<th>DEPENDENT FOR CAPACITY ONLY</th>
<th>INDEPENDENT FOR KNOWLEDGE &amp; CAPACITY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MODULAR</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suppliers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Few</td>
<td>Many</td>
<td></td>
</tr>
<tr>
<td>Clockspeed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fast</td>
<td>Slow</td>
<td></td>
</tr>
<tr>
<td>OK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Watch it!</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>INTEGRAL</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suppliers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Few</td>
<td>Many</td>
<td></td>
</tr>
<tr>
<td>Clockspeed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fast</td>
<td>Slow</td>
<td></td>
</tr>
<tr>
<td>OK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over-kill</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best</td>
<td>Out</td>
<td></td>
</tr>
<tr>
<td>In</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adapted from C. Fine, *Clockspeed*, Chapter 9
Strategic Sourcing Assessment requires evaluation of five key criteria:

- Customer Importance: High, Medium, Low
- Technology Clockspeed: Fast, Medium, Slow
- Competitive Position: Advantage, Parity, Disadvantage
- Capable Suppliers: None, Few, Many
- Architecture: Integral, Modular

Possible Decisions (Knowledge & Supply):
- Insourse
- Outsource
- Partner/Acquire
- Partial Insourse
- Partial Outsource
- Invest
- Spin Off
- Develop Suppliers
Sourcing Strategy Decision Tree - High Customer Importance Path

Model Developed by PRTM, Inc., GM Powertrain & Clockspeed, Inc.
Sourcing Strategy Decision Tree - Low Customer Importance Path

Model Developed by PRTM, Inc., GM Powertrain & Clockspeed, Inc.
Actual knowledge work compared to outcome of Decision Framework

Percentage of Knowledge Work Currently Done

- 0%
- 50%
- 100%

Percentage of Knowledge Work that Should be Controlled

- 0%
- 50%
- 100%

No Outsourcing
- Minimal Outsource - Equity/Acquire & Partner
- Minimal Outsource - Maintain Internal Knowledge
- Partial Outsourcing
- Mostly Outsource - Specify & Integrate
- Mostly Outsource - Develop More Suppliers
- Spin-off and Develop Suppliers
- Outsource All

Model Developed by PRTM, Inc., GM Powertrain & Clockspeed, Inc.
Every decision requires qualitative and quantitative analysis to reach a conclusion.

**Qualitative Strategic Model**

### Strategic Importance

**Quantitative Value**

**Knowledge**

**Supply**

- **Improve Economics**
- **Invest & Build**
- **Divest/Outsource**
- **Harvest Investment**

### Qualitative Value

- **High**
- **Low**

**Possible Decisions:**
- Insource
- Outsource
- Partner/Acquire
- Partial Insource
- Partial Outsource
- Invest
- Spin Off
- Develop Suppliers

### Knowledge

#### Technical
- Factory
- Battery
- Rim
- Tire

#### Financial
- NOPAT
- AS-IS
- BIC
- Capital Charge
- AS-IS
- BIC
- Transmissions EVA
- AS-IS
- BIC
- Engines EVA
- AS-IS
- BIC
- PBIT
- AS-IS
- BIC
- GMPT EVA
- NETRT
- Engine A EVA
- Engine B EVA
- Transmissions EVA
- Revenue
- −
- COGS
- Taxes
- Net Assets
- Working Capital
- Fixed Assets

**EVA**

**Quantitative Financial Model**

(Economic Value Added)

*Model Developed by PRTM, Inc., GM Powertrain & Clockspeed, Inc.*
Application of the Sourcing Model depends on integrality/modularity among Product, Process, & Supply

Product/Process Knowledge integral with manufacturing supply?

Product Knowledge

Process Knowledge

Manufacturing Supply

Product knowledge integral with process knowledge?

YES

NO

NO

YES

Product/Process Knowledge integral with manufacturing supply?
SUPPLY CHAIN DESIGN IS THE ULTIMATE CORE COMPETENCY

Since all advantages are temporary, the only lasting competency is to continuously build and assemble capabilities chains.

KEY SUB-COMPETENCIES:

1. Forecasting the dynamic evolution of market power and market opportunities

2. Anticipating Windows of Opportunity

3. 3-D Concurrent Engineering: Product, Process, Supply Chain

Fortune Favors the Prepared Firm
1. Benchmark the Fruit Flies
2. Map your Supply Chain
   - Organizational Supply Chain
   - Technology Supply Chain
   - Competence Chain
3. Dynamic Chain Analysis
   at each node of each chain map
4. Identify Windows of Opportunity
5. Exploit Competency Development Dynamics
   with 3-D Concurrent Engineering
Supply Chain Mapping

**Organizational Supply Chain**

- Chrysler
- Eaton
- casting supplier
- clay supplier

**Technology Supply Chain**

- engines
- valve lifters
- casting manufacturing process
- clay chemistry

**Capability Chain**

- Supply Chain Management
- Quality assurance
- NVH engineering
- R&D

**Underlying Assumption:** You have to draw the maps before you can assess their dynamics.
A 3-D CE decision model illustrating the imperative of concurrency
Components of Product, Process, and Supply Chain Strategy

- **Product**
  - Customer Needs
  - Market Segments
  - Product Architecture

- **Process**
  - Mission Statement
  - Operating Objectives
  - Policies & Procedures
    - Structural: Bricks, Tech, Org
    - Infrastructural: HR, Business Processes

- **Supply Chain**
  1. Sourcing: *Make/Buy*
  2. Supplier Selection
  3. Relationship Design
     *(spot, alliance, equity, etc.)*
  4. Logistics System Design
  5. Inventory Management Policies
  6. Supplier Management
  7. Supply Chain Architecture
Internet Era Phenomena: eCompetition in Business Model Design

E-tailing:
Attack: Amazon, Webvan
Defend: Walmart.com, Ford.com, Office Depot.com

B2B:
E2E integration: Cisco, Dell
Marketplace Creation: eSteel, Ariba, Freemarkets, Covisint
Product Development: Cisco

Customer as Product Manager:
Product Innovation/Pricing/Design/Spec/Tracking/Delivery: Dell, Herman Miller, Reflect, iMotors, FedEx, Priceline

Free & Open Digital Content:
Constructive Collaboration: Linux, Lego, Palm Pilot
“Anarchistic Constructive” Conversation: Cluetrain
Ubiquitous Sharing/Theft: Napster, FreeNet, Gnutella
Patterns in eBusiness Disruption

Disruption

B2C
- AMAZON
- WEBVAN
- iMOTORS

B2B
- ARRIBA
- FREEMARKETS

E2E
- DELL
- NAPSTER

Defense

B2C
- WALMART
- FORD
- CVS

B2B
- COVISINT
- iPAPER

E2E
- FORD OTD
- HERMAN MILLER

New Value Add/Collab.

B2C
- LIVING.COM
- REFLECT.COM

B2B
- CISCO PDT DEV

E2E
- LINUX
- LEGO
Categorizing Business Webs: What are the dimensions?
(adapted from Digital Capital, Tapscott, Ticoll, & Lowy, HBSP, 2000)
Cisco’s E2E Integration for Fulfillment & Product Development

- New product development on-line with supply base
- Technology Supply Chain Design: Innovation through Acquisition

Customers

Order info flows direct to Cisco and suppliers

Cisco

Contract Manufacturers

• Single enterprise information system
• Dynamic replenishment, direct fulfillment, merge in transit
• Customer orders through Cisco Connection online

Finished Product flows direct to customer via logistics supplier

Component Suppliers & Distributors
Cisco’s Value Chain Design

**Product Design**
- minimal prototype iteration
- shared product databases
- highly modular products
- joint with suppliers

**Process Design**
- orders go from CCO website to CM’s
- products go from CM’s to customer via logistics supplier
- order & forecast data online to supply chain

**Supply Chain Design**
- innovation through acquisition
- outsourced manufacturing (e.g., Solectron)
- outsourced logistics (e.g., Fedex)
- independent for knowledge in IT system
Auto Example: Three Technological Disruptions
Each could trigger structural change

Internet-driven eBusiness

Value Chain Restructurings & Disintermediation, B2B marketplace, Build-to-Order Systems, Modularity & Outsourcing, Customer Configuration (B2C), End-to-End (E2E) integration

Telematics

Services for
  Safety, Navigation, Concierge, Productivity, & Entertainment
Value Chain Implications, e.g., “Nokia & Sprint Inside”
Vehicle Architecture (Open vs. Closed), Revenue Model Impacts

Powertrain Innovations

Hybrid & Fuel Cell Technologies as potentially disruptive and re-inforcing of industry de-verticalization
Benchmark the Fruit Flies
• Beware of Intel Inside
• SC control point unstable
  (comp, assem, distrib)
• SC structures oscillate
  -- int/int or mod/mod
• Cisco is open & modular: PDT & SC
• Dependence/Independence has positive feedback
• Projects feed capabilities & vice-versa
• eBusiness accelerates Clockspeeds
• All Advantage is Temporary
• Align Architectures in Pdt, Proc, & SC

QUESTIONS
• Does Amazon need Warehouses?
• Or should they buy Fedex?
• Can Delphi be the Cisco of mobile media?
• Can Ford be the Dell of Cars?
• Is Dell done innovating?
• How can P&G get tree-to-toilet time down to seven days?
• What comes after open & modular?
• When will brick/click integration pay?
• When not?
All Conclusions are *Temporary*

Clockspeeds are increasing almost everywhere

eCommerce is a clockspeed driver

Supply chain design is a key competency

Study of eFlies can help with crafting strategy