Chapter-12 Product Architecture

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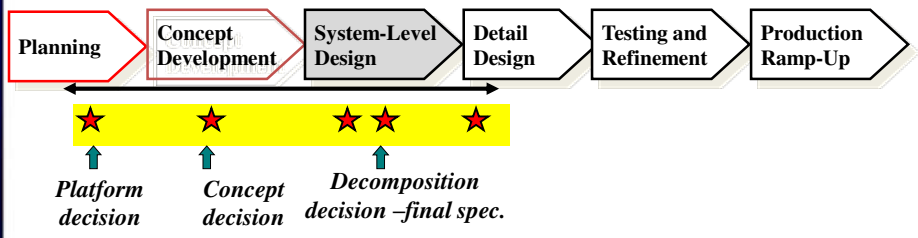
What is The system Level Design?

Product Development Process



What is the system level design?

It is the phase which defines the product architecture and it subassemblies and components

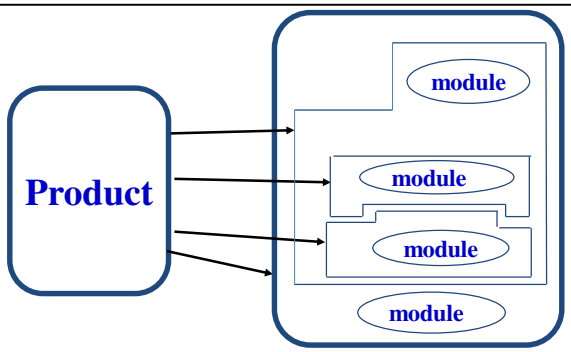
Product architecture is determined early in the development process.

Output of the phase:

- Product geometric layout
- Flow diagram for final assembly process

Product Architecture: Definition

The arrangement of functional elements into ***physical chunks*** which become ***the building blocks*** for the product or family of products.



It describes how product/ system functional elements are assigned to its components/ subsystems and how they interact.

Product Architecture: Definition

An architecture has a two-part definition:

1) An architecture is a decomposition of the overall functionality of a product into a set of defined functions and the component parts of the product that are going to provide those functions.

2) An architecture is the specification of the interface between the components, in other words, how components are going to interact together in the product as a system. This is critical to the design of flexible architectures that allow you to substitute component variations within a product without having to make adjustments in other components."

- Ron Sanchez : *Professor of Strategy and Technology Management at IMD*
http://weblogs.java.net/blog/johnreynolds/archive/2006/04/product_archite.html

Modular Product Architectures

- Chunks implement one or a few functions entirely.
- Interactions between chunks are well defined.
- Modular architecture has advantages in simplicity and reusability for a product family or platform.

Swiss Army Knife

Sony Walkman

Platform Architecture of the Sony Walkman

Integral Product Architectures

- Functional elements are implemented by multiple chunks, or a chunk may implement many functions.
- Interactions between chunks are poorly defined.
- Integral architecture generally increases performance and reduces costs for any specific product model.

High-Performance Wheels

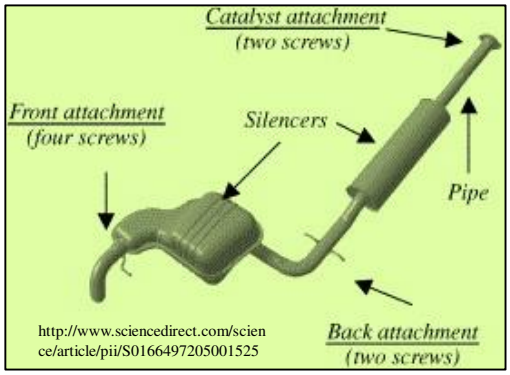
Compact Camera

What is this?

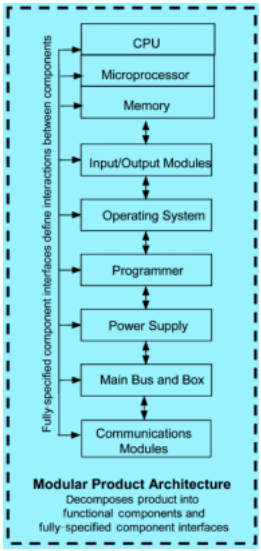
http://www.architecture-page.com/go/products/palm-chair

http://www.thinkgeek.com/gadgets/tools/e2dc/

What is this?



http://www.sciencedirect.com/science/article/pii/S0166497205001525



http://www.sciencedirect.com/science/article/pii/S0024630101000991

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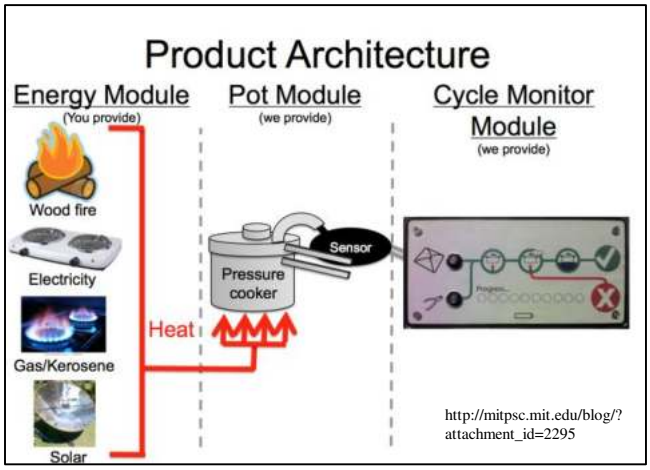

http://mitpsc.mit.edu/blog/?attachment_id=2295

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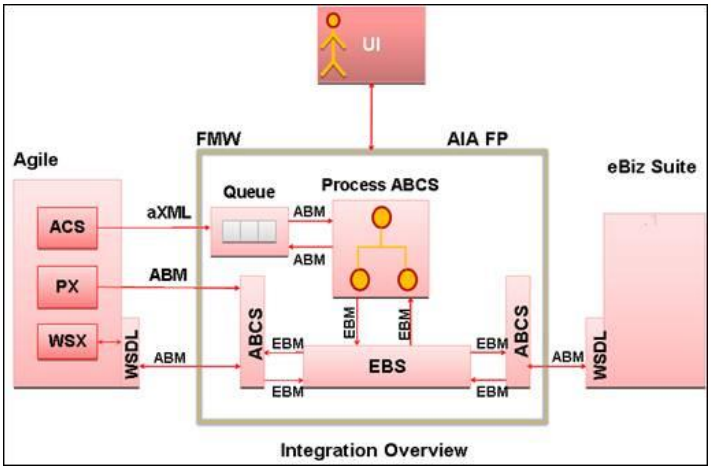
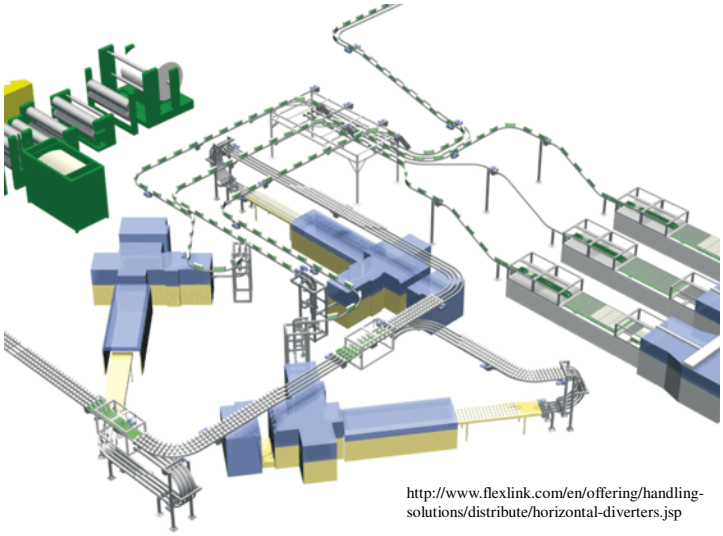


Oracle® Application Integration Architecture Agile Product Lifecycle Management Integration Pack for Oracle E-Business Suite: Design to Release Implementation Guide

http://docs.oracle.com/cd/E24010_01/doc.111/e22280/chap1.htm

What is this?



http://www.flexlink.com/en/offering/handling-solutions/distribute/horizontal-diverters.jsp

What is this?

http://www.pneumatictoolsonline.com/DesoutterTools/HTML/SCREWDRIVERS/Desoutter-Catalog.htm

Ford Taurus : Integrated Control Panel

Modular or Integral Architecture?

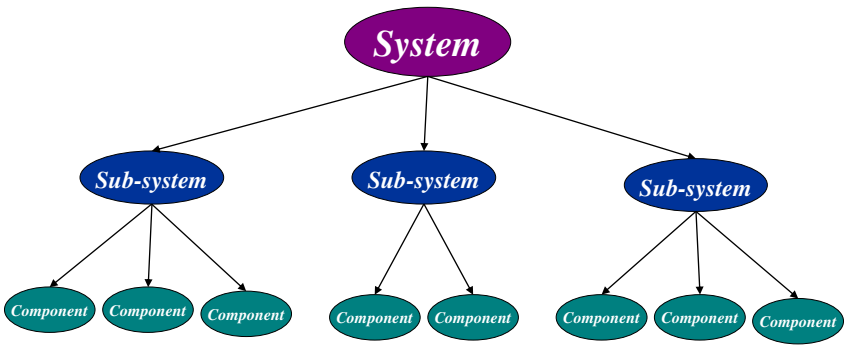
Motorola StarTAC
Cellular Phone

Apple
iBook

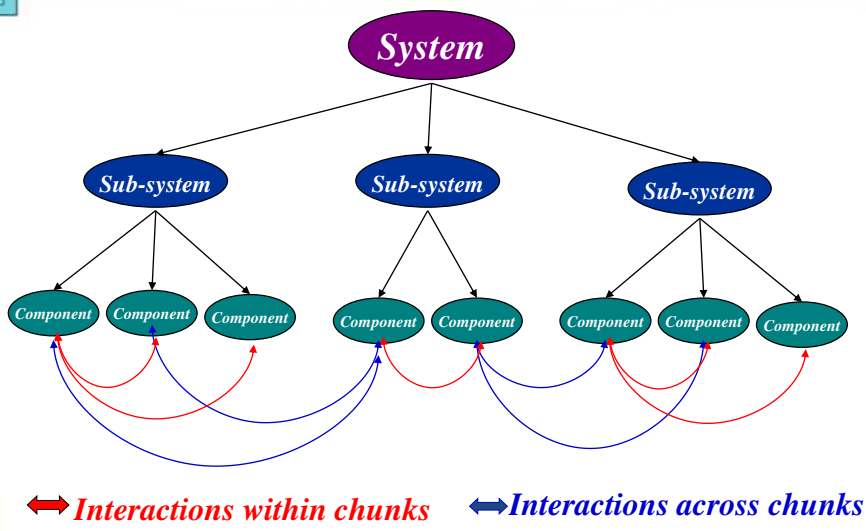
Ford
Explorer

Rollerblade
In-Line Skates

The concepts of integral and modular apply at several levels:



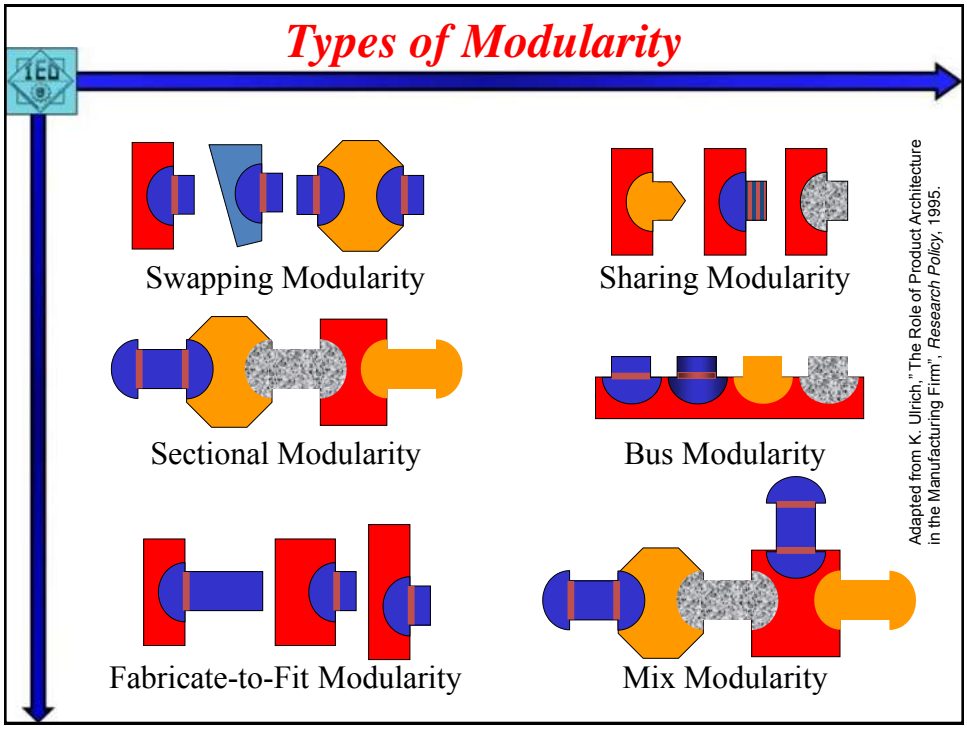
Product Architecture = Decomposition + Interactions

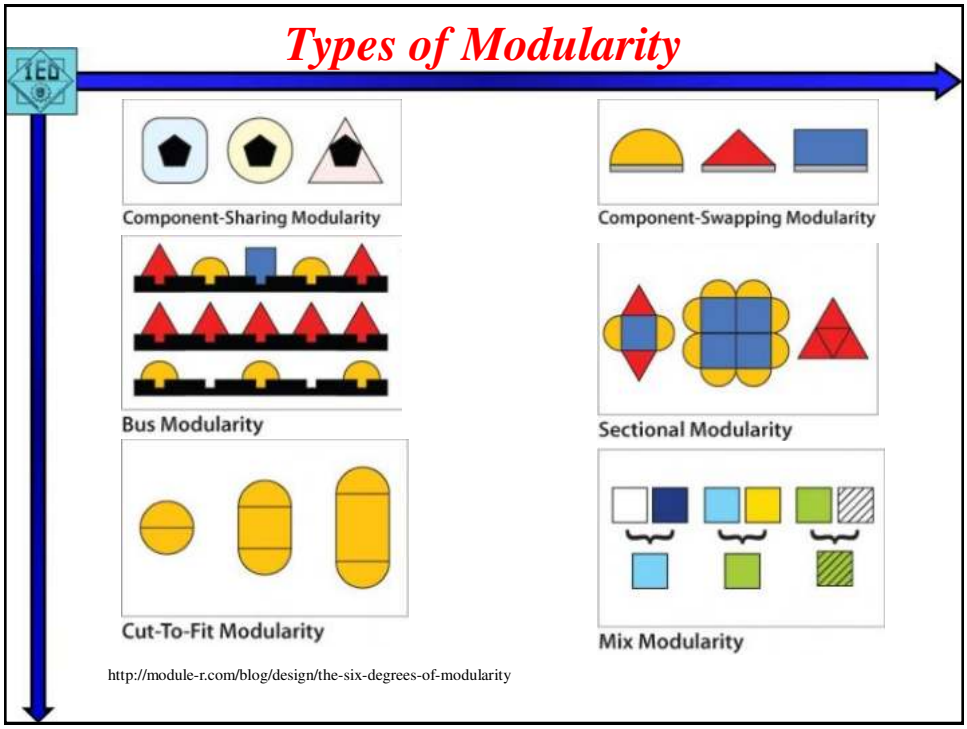


Choosing the Product Architecture

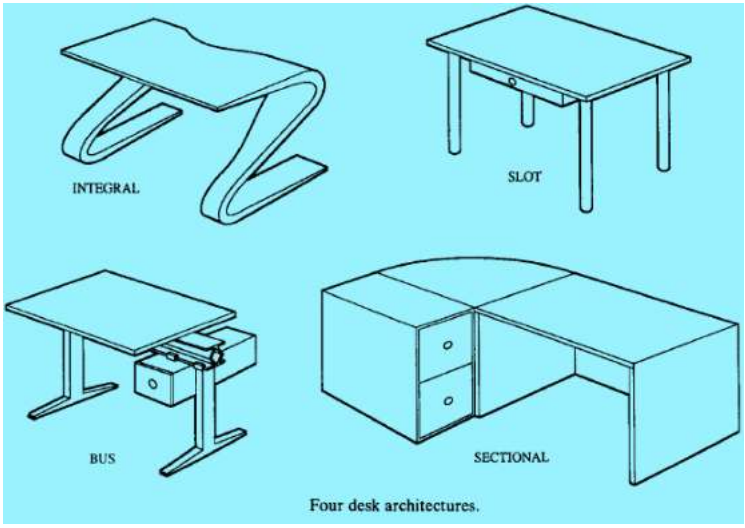
Architecture decisions relate to product planning and concept development decisions:

- ***Product Change*** (copier toner, camera lenses)
- ***Product Variety*** (computers, automobiles)
- ***Standardization*** (motors, bearings, fasteners)
- ***Performance*** (racing bikes, fighter planes)
- ***Manufacturing Cost*** (disk drives, razors)
- ***Project Management*** (team capacity, skills)
- ***System Engineering*** (decomposition, integration)


Types of Modularity
Swapping Modularity
Sharing Modularity
Sectional Modularity
Bus Modularity
Fabricate-to-Fit Modularity
Mix Modularity
Adapted from K. Ulrich, "The Role of Product Architecture in the Manufacturing Firm", Research Policy, 1995.


Types of Modularity
Component-Sharing Modularity
Component-Swapping Modularity
Bus Modularity
Sectional Modularity
Cut-To-Fit Modularity
Mix Modularity
http://module-r.com/blog/design/the-six-degrees-of-modularity

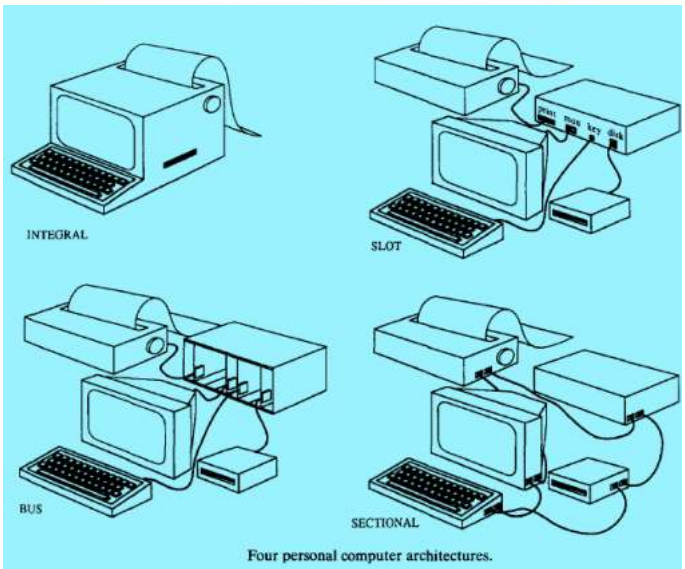
Deck Example: Type of Architecture



Four desk architectures.

Karl Ulrich; The role of product architecture in the manufacturing firm, Research Policy 24 (1995) 419-441)

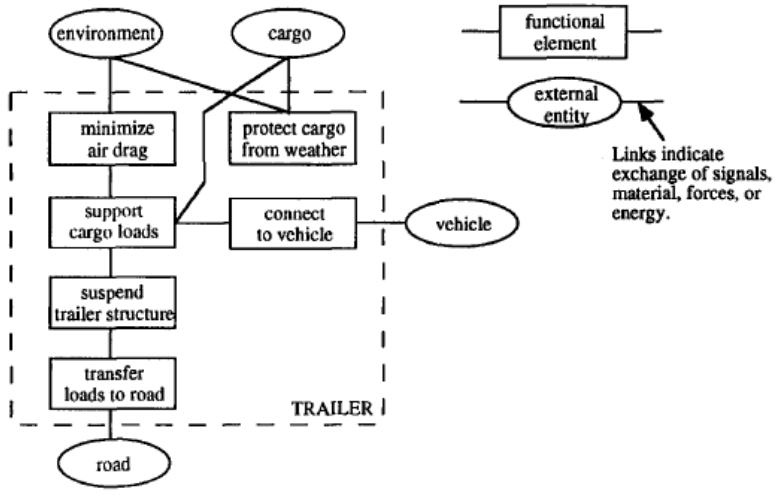
Deck Example: Type of Architecture



Four personal computer architectures.

Karl Ulrich; The role of product architecture in the manufacturing firm, Research Policy 24 (1995) 419-441)

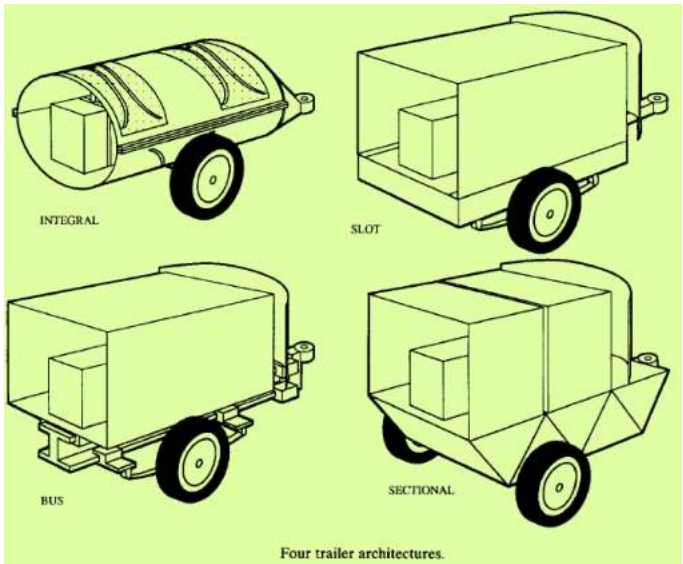
Trailer Example: Modular Architecture



A function structure for a trailer.

Karl Ulrich; The role of product architecture in the manufacturing firm, Research Policy 24 (1995) 419-441)

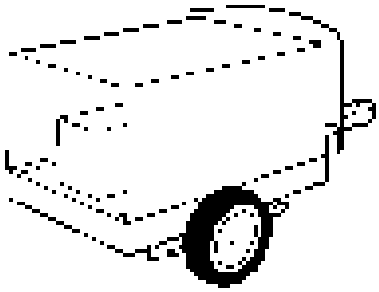
Trailer Example: Various Architecture



Four trailer architectures.

Karl Ulrich; The role of product architecture in the manufacturing firm, Research Policy 24 (1995) 419-441)

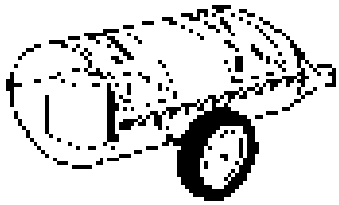
Trailer Example: Modular Architecture



box	Protect cargo from weather
hitch	Connect to vehicle
fairing	Minimize air drag
bed	Support cargo loads
springs	Suspend trailer structure
wheels	transfer loads to road

Karl Ulrich; The role of product architecture in the manufacturing firm, Research Policy 24 (1995) 419-441)

Trailer Example: Integral Architecture



Spring slot covers	Protect cargo from weather
Upper half	Suspend trailer structure
Lower half	
Nose piece	Connect to vehicle
	Minimize air drag
Cargo hanging straps	Support cargo loads
Wheels	Transfer loads to road

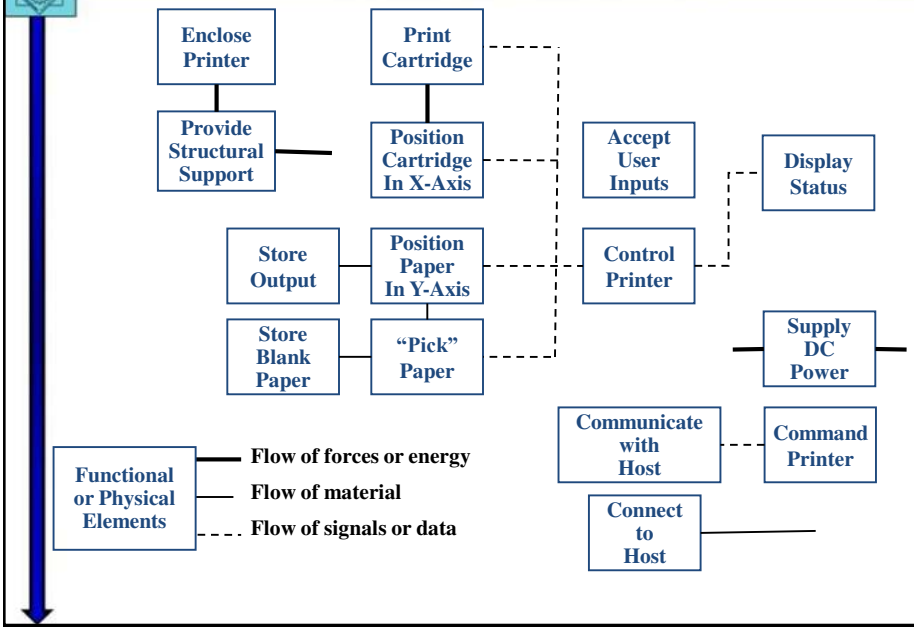
Karl Ulrich; The role of product architecture in the manufacturing firm, Research Policy 24 (1995) 419-441)

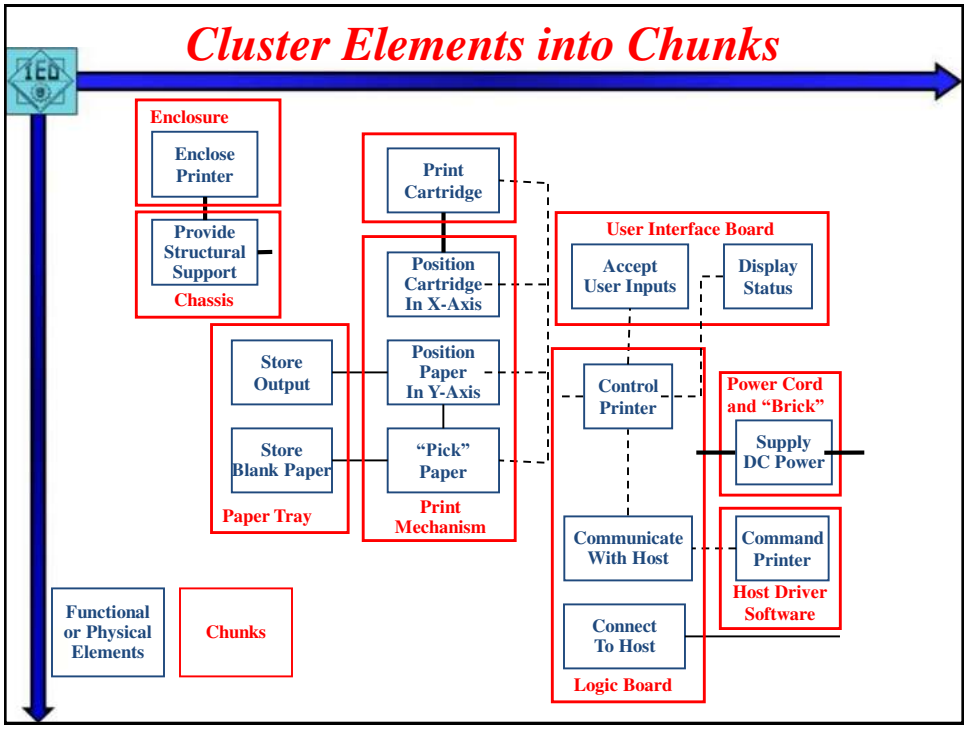
Establishing the Architecture

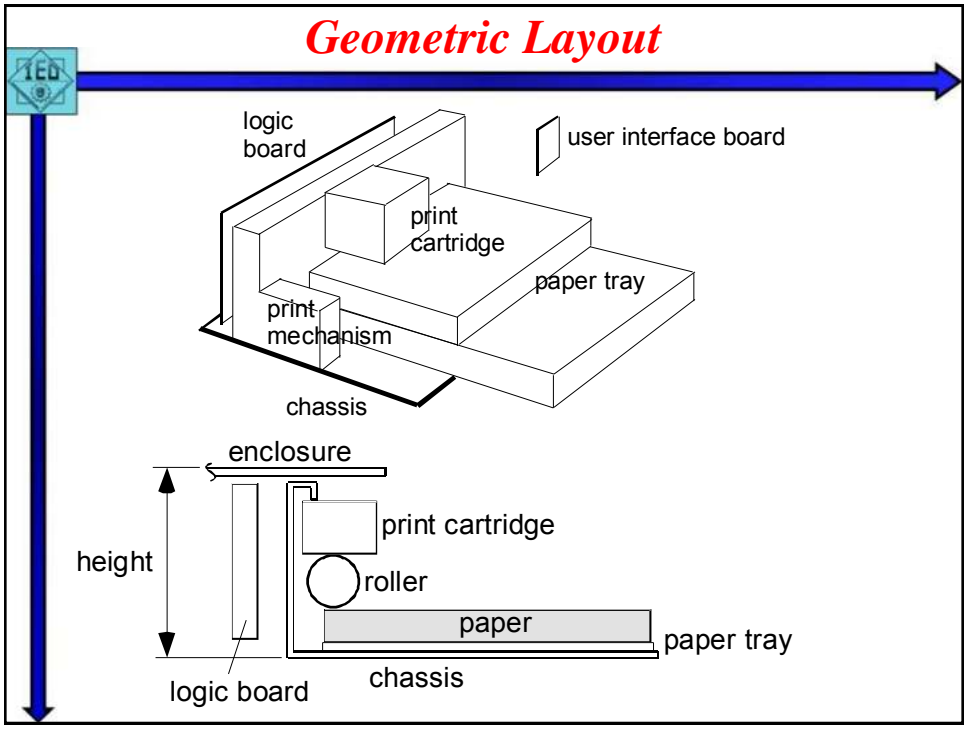
To establish a modular architecture;

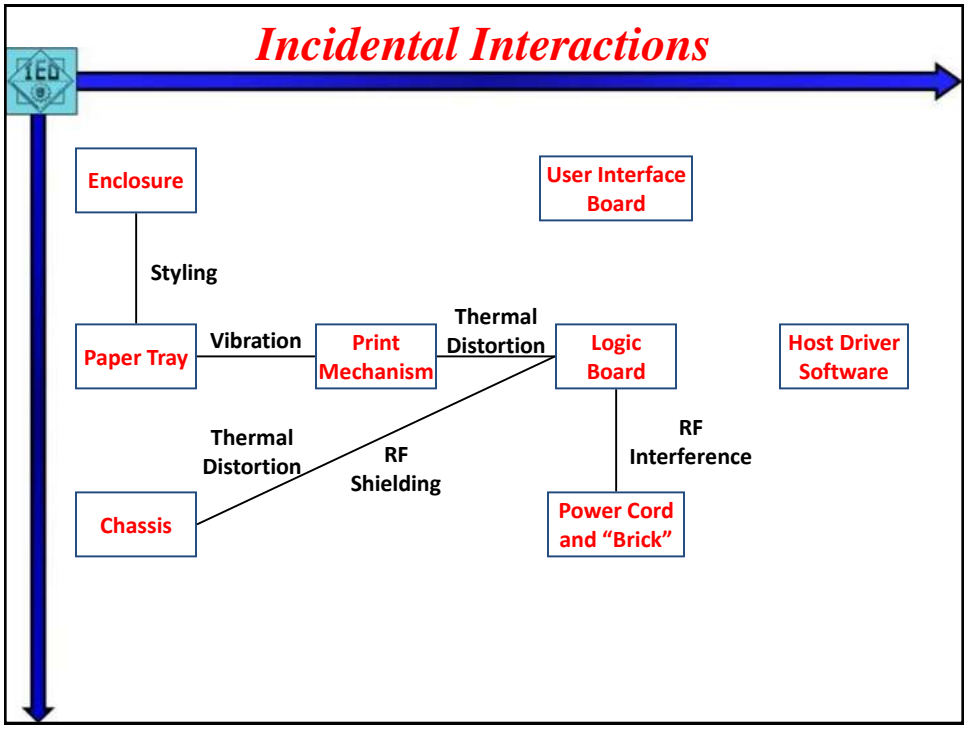
- Create a schematic of the product, and
- Cluster the elements of the schematic to achieve the types of product variety desired.

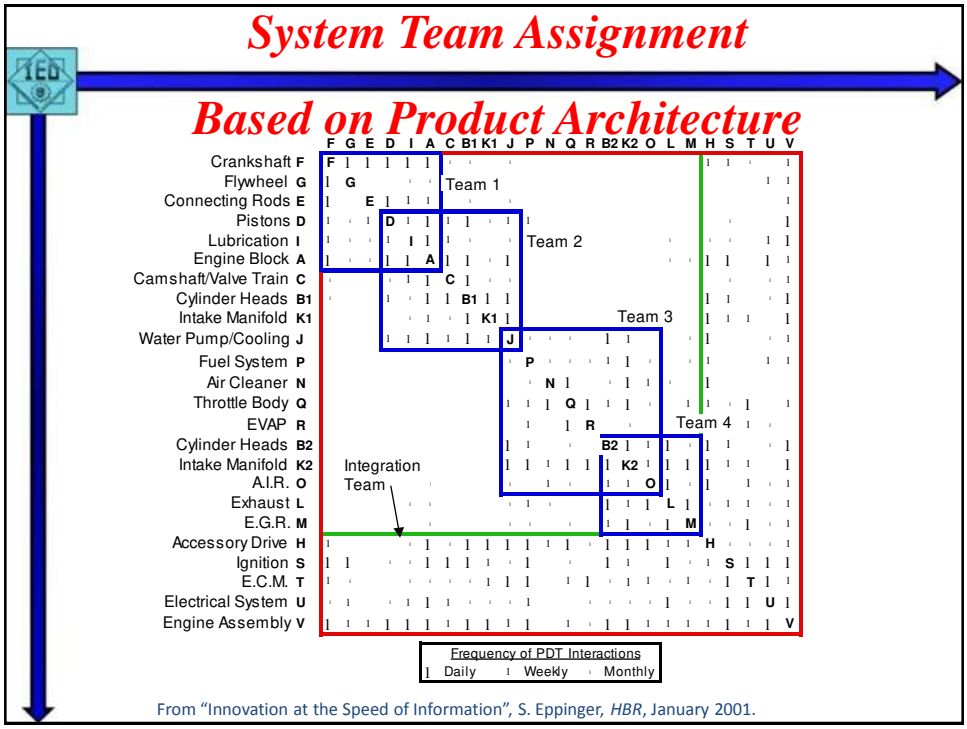
DeskJet Printer Schematic




Cluster Elements into Chunks
Enclosure
Enclose Printer
Provide Structural Support
Chassis
Print Cartridge
Position Cartridge In X-Axis
Position Paper In Y-Axis
"Pick" Paper
Print Mechanism
Store Output
Store Blank Paper
Paper Tray
User Interface Board
Accept User Inputs
Display Status
Control Printer
Logic Board
Power Cord and "Brick"
Supply DC Power
Communicate With Host
Connect To Host
Command Printer
Host Driver Software
Functional or Physical Elements
Chunks


Geometric Layout
logic board
user interface board
print cartridge
paper tray
print mechanism
chassis
enclosure
height
print cartridge
roller
paper
paper tray
logic board
chassis





From "Innovation at the Speed of Information", S. Eppinger, *HBR*, January 2001.

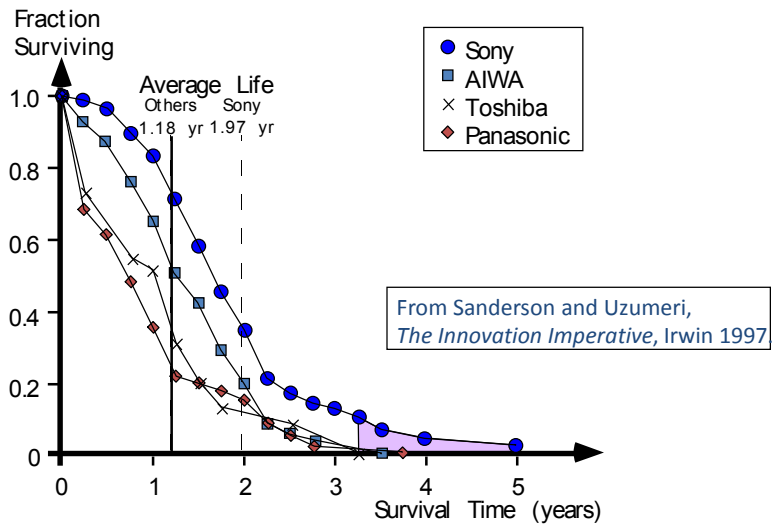
Planning a Modular Product Line: Commonality Table

Chunks	Number of Types	Family	Student	SOHO (small office, home office)
Print cartridge	2	"Manet" Cartridge	"Picasso" Cartridge	"Picasso" Cartridge
Print Mechanism	2	"Aurora" Series	Narrow "Aurora" series	"Aurora" series
Paper tray	2	Front-in Front-out	Front-in Front-out	Tall Front-in Front-out
Logic board	2	"Next gen" board with parallel port	"Next gen" board	"Next gen" board
Enclosure	3	Home style	Youth style	"Soft office" style
Driver software	5	Version A-PC Version A-Mac	Version B-PC Version B-Mac	Version C

Differentiation versus Commonality

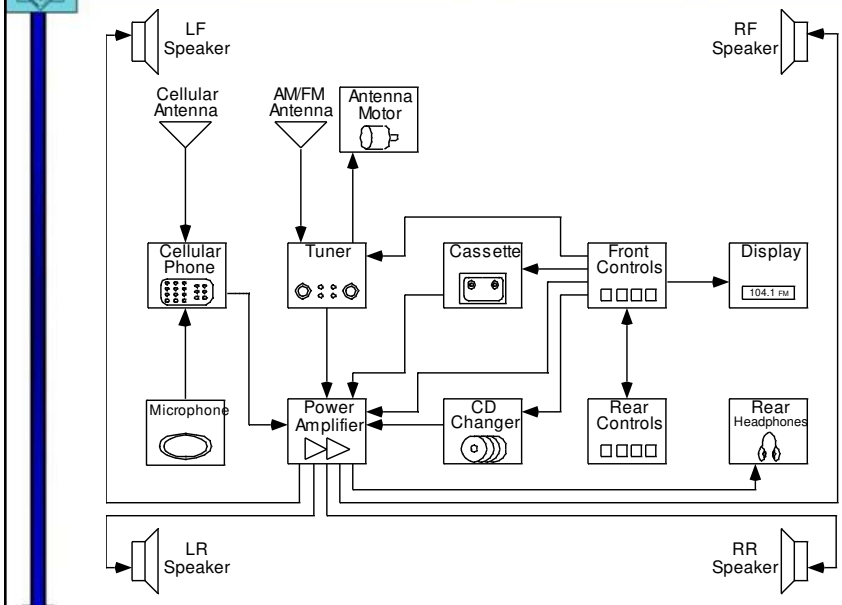
Trade off product variety and production complexity

Product Model Lifetime



From Sanderson and Uzumeri, *The Innovation Imperative*, Irwin 1997

Audio System Exercise: Where are the Chunks?



Fundamental Decisions

- Integral vs. modular architecture?
- What type of modularity?
- How to assign functions to chunks?
- How to assign chunks to teams?
- Which chunks to outsource?

Practical Concerns

- Planning is essential to achieve the desired variety and product change capability.
- Coordination is difficult, particularly across teams, companies, or great distances.
- Special attention must be paid to handle complex interactions between chunks (system engineering methods).

Conclusions

- Architecture choices define the sub-systems and modules of the product platform or family.
- *Architecture determines:*
  - ease of production variety
  - feasibility of customer modification
  - system-level production costs
- *Key Concepts:*
  - modular vs. integral architecture
  - clustering into chunks
  - planning product families