Product Design & Development

Product Architecture
Questions

- How would the architecture of the product impact their ability to offer product variety?
- What would be the cost implications of different product architectures?
- How would the architecture of the product impact their ability to complete the design within 12 months?
- How would the architecture of the product influence their ability to manage the development process?
What is Product Architecture

- A product can be thought in both functional and physical terms.
- The functional elements are the individual operations and transformations.
- The physical elements of a product are the parts, components, and subassemblies.
- The physical elements of a product are typically organized into several major physical building blocks, called chunks.
What is Product Architecture?

- Product architecture is the assignment of the product's functions to physical building blocks or "chunks".
Modular or integral architecture?
Modular product architecture

- Each chunk fully embodies one or more product functions.
  - Interactions between chunks are:
    - well defined
    - (typically) fundamental to product's primary functions.
  - Modular architecture has advantages in simplicity and reusability for a product family or platform.
Modular product architecture

- Modular architecture has advantages in simplicity and reusability for a product family or platform.
Platform Architecture of the Sony Walkman
Integral product architecture

- Typical functions involve more than one chunk
- Typical chunks implement more than one function
- Interactions between chunks are ill-defined and may be incidental to product's primary functions.
- Integral architecture generally increases performance and reduces costs for any specific product model.
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
Trailor Example: Integral Architecture

- upper half
- lower half
- nose piece
- cargo hanging straps
- spring slot covers
- wheels

- protect cargo from weather
- connect to vehicle
- minimize air drag
- support cargo loads
- suspend trailer structure
- transfer loads to road

ETM 551 - Product Architecture
Modularity

- Modularity is a relative property
- Products are rarely strictly modular or integral.
Types of modularity

- **Slot-modular architecture**
  - Each chunk-to-chunk interface is different from the others.

  Chunks cannot be swapped around.
Slot-modular architecture

- Each interface between chunks in a slot-modular is of a different type from the others, so that the various chunks in the product cannot be interchanged (e.g. Automobile radio)
Bus-modular architecture

- Uses a **common bus**, or similar concept.

- Uses standard chunk-to-bus interfaces.
Sectional-modular architecture

- No common bus or other single element interfacing with all other chunks.
- Uses standard chunk-to-chunk interfaces.
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)
When is the product architecture defined?

Product architecture begins to emerge during concept development.

- Platform decision
- Concept decision
- Decomposition decision
Product architecture affects:

- **Product changes**
  - **Upgrades**
    - Ex.: Changing the processor board of a computer
  - **Add-ons**
    - Ex.: Third-party mass storage devices
  - **Adaptation to local conditions**
    - Ex.: 110 or 220 Volt power supply
Product architecture affects:

- High-wear components
  Ex.: tires on vehicles
- Consumables
  Ex.: film cartridges
- Flexibility in use
  Ex.: Lens or flash options for a camera
- Resuse
  Ex.: consumer electronics manufacturers
Product variety

- Variety refers to the range of product models the firm can produce within a particular timeframe in response to market demand.

  - Swatch produces hundreds of watch models.
Component standardization

- Use the same components or chunks in various products.
  - Ex.:
    Watch movement, watch battery, etc.
Product performance

- How will product implement intended functions?
  - Ex.: Function sharing of BMW transmission chunk
Manufacturability

Benefits from:

- Design-for-manufacturing (DFM)
- Minimization of parts count through component integration.

These strategies are best applied at the chunk level.
Managing the PD process

- Detailed design responsibility for each chunk is usually assigned to a small in-house team or outsourced to a supplier.
Concepts of integral and modular apply at several levels

- System
- Sub-system
- Component
Product Architecture = Decomposition + Interactions

Interactions within chunks

Interactions across chunks
Establishing the architecture

- Create schematic (illustrating product architecture)
- Cluster elements
- Create rough geometric layout
- Identify fundamental and incidental interactions
DeskJet Printer Schematic

- Enclose Printer
- Provide Structural Support
- Store Output
  - Store Blank Paper
- Print Cartridge
  - Position Cartridge In X-Axis
  - Position Paper In Y-Axis
- “Pick” Paper
- Accept User Inputs
- Control Printer
- Display Status
- Supply DC Power
- Communicate with Host
  - Connect to Host
- Connect Printer

Flow of forces or energy
Flow of material
Flow of signals or data
Clustering elements

- Key considerations when clustering elements (of schematic) into chunks include:
  - Geometric integration and precision
    - Ex.: H-P clustering for ink-jet printer calls for cartridge positioning on x-axis and paper positioning on y-axis
Clustering elements (cont)

- Function sharing
  - Ex.: Status display and user controls for H-P printer
  - Ex.: Transmission for BMW motorcycle

- Vendor (= Supplier) capabilities
  - Ex.: H-P printer
  - Ex.: Spring and shock absorber for rear suspension of BMW motorcycle
Clustering elements (cont)

- Similarity of design or production technology
- Location of change
- Accommodating variety
- Enabling standardization
- Portability of interfaces
Cluster Elements into Chunks

- Enclosure
  - Enclose Printer
  - Provide Structural Support
    - Chassis

- Paper Tray
  - Store Output
  - Store Blank Paper

- Print Mechanism
  - Print Cartridge
    - Position Cartridge In X-Axis
    - Position Paper In Y-Axis
    - "Pick" Paper

- Logic Board
  - Connect to Host
  - Communicate with Host

- User Interface Board
  - Accept User Inputs
  - Display Status

- Command Printer
  - Supply DC Power

- Power Cord and "Brick"

- Host Driver Software

- Functional or Physical Elements
  - Chunks
Audio System Exercise: Where are the Chunks?
Geometric layout

Key considerations when creating a rough geometric layout include:

- Identification of fundamental and incidental interactions
  - Fundamental interactions
    - Ex.: H-P printer
      Sheets of paper flow from the paper tray to print mechanism.
  - Incidental interactions
    - Ex.: Vibration induced by the actuators in paper tray may interfere with precision positioning of print cartridge (x-axis)
Create a rough geometric layout

- logic board
- chassis
- paper tray
- print cartridge
- print mechanism
- user interface board

- enclosure
- height
- roller
- paper
- paper tray
- logic board
- chassis
Incidental interactions

- Enclosure
- Paper Tray
- Chassis
- User Interface Board
- Logic Board
- Power Cord and “Brick”
- Host Driver Software

- Styling
- Vibration
- Thermal Distortion
- Thermal Distortion
Frequency of PDT Interactions

- Daily
- Weekly
- Monthly
Variety and supply chain considerations

**Exhibit 9-10**

Postponement involves delaying differentiation of the product until late in the supply chain. In Scenario A, six versions of the product are created during assembly and before transportation. In Scenario B, the six versions of the product are not created until after transportation.
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).
Product Architecture: 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
Summary

- Product architecture decisions affect product change, product variety, component standardization, product performance, manufacturability, and PD management.

- A key characteristic of a product architecture is the degree to which it is modular or integral.
Summary

- Four steps for product architecture
- 1. Create a schematic of the product
- 2. Cluster the elements of the schematic
- 3. Create a rough geometric layout
- 4. Identify the fundamental and incidental interactions