ECE-492
SENIOR ADVANCED DESIGN PROJECT
Meeting #4
HW1: Teams – show us your Requirements Specification?

HW2: Teams – show us your Conceptual Design?
“At Sony, we assume all products of our competitors will have basically the same technology, price, performance, and features. Design is the one thing that differentiates one product from another in the marketplace”

Norio Ohgo, Chairman and CEO, Sony
Design Directions
Bottom-Up vs. Top-Down

- **Bottom-up**
  - The designer starts with basic components and synthesizes them to create the overall system
    - Consider designing a car from many parts – Will the final product meet requirements?
  - Pros: Leads to efficient subsystem
  - Cons: Difficult to meet requirements; Complexity difficult to manage; Difficult redesign

- **Top-down (!!!)**
  - The designer has an overall vision of what the final system must do, and the problem is partitioned into subsystems that work together to achieve the goal
    - Opportunity to consider radically different solutions (!)
  - Pros: Highly predictable design cycle; Full utilization of requirements; Efficient development of large systems
  - Cons: More time spent in planning; May limit creativity
STEP 4:
FUNCTIONAL ARCHITECTURE

- A logical model that defines what the system must do
- Achieved through an iterative process of top-down functional decomposition

- You take what you have done for Concept Sketching and refine into greater detail, in a more systematic way
  - Look at Concept Sketching as ‘a proposition’
  - Now refine your ‘proposition’ into: **Functional Architecture**, and later into Physical Architecture, and System Architecture
  - Later follow deeper into a blueprint in order to build/implement your system
Black-Box Design

- This is your first design step

- System as a box, without knowing what is inside
  - Refer to requirements specification all the time
  - This step helps to:
    - Define interfacing methods with people, environment, other systems
    - Define protocols of operating your system
    - Refine top-level functions/operations for the system

![Diagram showing inputs, outputs, user, controls, environment, other influences, and list of top-level functions.](image-url)
White-Box Design

- This your second design step

- Applied only after Black-box design

- You design a system with an understanding what the internal functions are and the connections between them

- Functional decomposition is the most pervasive design technique at this stage
Functional Decomposition

- **Functional Decomposition Process**
  - Identify top level functions the system must perform
  - Functions may ultimately be accomplished through the actions of the equipment, software, people
  - Specify “whats” (not “hows”)
  - Iteratively keep decomposing functions onto lower-level functions
  - Include system response to unexpected inputs and to failures

- **Functional Flow Block Diagram**
  - End product of functional decomposition
  - Used to illustrate organizational breakdown and major interfaces
Level-0

Top-Level Functions (Functions A, B, C, D, E, F)

Level-1

Function A  Function B  Function C  Function D

Function E

Function F

Level-2

E.1  E.2  E.4  E.5

E.3

E.3  E.6

Relations between top-level functions

Relations between second-level functions

Figure: System functional breakdown
CASE STUDY:
Clock Timer

< Step 4: Functional Decomposition >
Develop:

- System Functional Breakdown at Level-0 and Level-1
- System Functional Breakdown at Level-2 (you will modify it after proposal presentation)

Your functional breakdown must be at a such level so that you can explain the process with greater detail

Advice:

- Pick up 2-3 operational scenarios and trace them through your functional architecture
- Can you describe these scenarios within your functional architecture?
- Can you describe what happens when a failure occurs?
STEP 5: SYSTEM ARCHITECTURE

Step 1: Physical Architecture

Step 2: Component selection

Step 3: System Architecture diagram
Physical Architecture: Hierarchical Model

- The Physical Architecture includes a description of the resources that comprise the system.
- Hierarchy begins with the system block, system top-level components/modules, and progresses down to the Configuration Items (CI).
- CI can be:
  - Hardware or software element
  - Combination of hardware and software
  - People, Facilities
  - Procedures, Documents
Physical Architecture

Ask yourself a question:

“What are physical resources needed to perform system functions defined in functional architecture”

- Start from the top and define main modules
- Modules/components are responsible for handling specific functionality at higher level
- Add supporting modules; such as power supply, enclosure, etc. (Refer to requirements specification)
- Follow down by decomposing these modules into a hierarchical tree
- Do not link these modules/components into an operational system (not yet !)
- Do not think in terms of specific parts (!)
Elevator System Design: Generic Physical Architecture

Component Selection

- Search through COTS products, components, parts, software components/modules, etc.
- Select these which are needed to develop your system
  - Meaning; needed to implement system functions
- Identify primary components and alternatives
- This selection is also guided by requirements specification
  - Technology, Power, Safety and regulations, Cost
- Allocate selected components to the blocks of physical architecture
  - Resulting in Specific Physical Architecture
System Architecture

- When someone says “system architecture” then it means:
  - This is where the final design comes together
  - Final product of integrating Functional Architecture, Physical Architecture, and Requirements
    - Process of Functional Allocation to subsystems
- The most descriptive diagram for illustration of system operations
- Use it in your presentations and work planning
Functional Allocation

- Group similar functions into logical subdivisions
- Conversion of the “whats” into ‘hows”
- Allocation to physical components – probably the most crucial design decisions to be made

Note:
- The same functionality can be performed through different means; for example:
  - Function of signal filtering can be implemented by a hardware or a software component
- Therefore, your system architecture will be a product of a search through many alternatives
Figure: Functional allocation
CASE STUDY:
Clock Timer

< Step 5: System Architecture >
Summary:
Physical Architecture in ECE492

➢ For your Proposal:
  o Physical Architecture – brief hierarchical model
  o System Architecture – diagram w/ main components

➢ For your Proposal Presentation:
  o System Architecture – diagram w/ main components

➢ Be able to illustrate a mapping of Functional Architecture onto System Architecture

➢ If specific parts are already known then annotate them on the system architecture diagram
PROPOSAL

- Each team needs to prepare and defend a project proposal
- Proposal is a formal document explaining:
  - The need
  - Proposed technological solution (Technical section)
  - Team capability and plan to undertake the effort (Administrative section)
- Proposal defense is a formal presentation
- Educate yourself on:
  - Background phenomenology needed to solve a given problem (!)
  - Technical solution you propose
  - Top-down design process, system architecture
  - Systems engineering practice (project management)
Proposal Preparation

- Your proposal is a formal document representing you!
  - Don’t forget about nice printout, cover, etc.
  - Drawings must be nice, clean, and readable
- Look from a perspective that you compete for a limited pool of money
  - It means, the best proposals win and get funded
  - You have to attract a reader to your proposed work
  - But, it cannot be a marketing document
  - Be realistic
  - Say something about the team and your skills
  - Write very well in a narrative form – get English checked
  - Pay particular attention to the Executive Summary
Proposal Format

1) Cover Page
2) Executive Summary (1/2 – 1 page)
3) Problem Statement (1 – 2 pages)
   - Motivation
   - Identification of need
   - Market/application review
4) Approach (3 – 6 pages)
   - Problem analysis (w/ external system diagram)
   - Approach (based on conceptual design)
   - Alternative approaches
   - Introduction to background knowledge/phenomenology supporting the project
   - Project requirements specification
5) System Design (3 – 6 pages)
   - Functional decomposition
   - System architecture

6) Preliminary Experimental Plan (1 – 2 pages)
   - Selection of requirements for experimental validation
   - List of 2-3 experiments to be conducted next semester

7) Preliminary Project Plan (1 – 2 pages)
   - Short list of task for ECE493 (based on system architecture and functional decomposition)
   - Allocation of responsibilities

8) Potential Problems
   - Knowledge and skills to be learned
   - Brief project risk analysis, etc.

9) References
   - Literature references; Web URLs, etc.
   - People contacted
For the Next Meeting

- Read textbook – Chapters 5
- Have questions about proposal preparation and presentation
- Next meeting:
  System design II; Early prototyping; Proposal presentation

Homework for the next meeting:
- Bring hard copies of
  - Functional Architecture
  - System Architecture