



Introduction to Embedded Systems

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Objectives

- Categories Of Embedded Systems
- Design Constraints
- Design challenges
- Design Metrics
- Trade off in Design metrics

Categories of Embedded Systems

- **Standalone embedded systems**
 - Work in stand-alone mode
 - Take inputs, process them and produce desired output.
 - Used in process control, automobiles, consumer electronics etc.

Categories of Embedded Systems

- Real time Systems
 - With strict Deadlines called hard real time systems
 - Little delay won't cause serious implications, termed as soft real time systems.

Categories of Embedded Systems

- Networked information appliances
 - Provided with network interfaces and accessed by networks such as LAN or Internet
 - The door lock of a house with TCP/IP and HTTP server running on it.

Categories of Embedded Systems

- **Mobile Devices**
 - Mobile phones
 - Personal digital Assistant etc.

Design Constraints

- ◆ **Small Size, Low Weight**
 - Hand-held electronics
 - Transportation applications -- weight costs money
- ◆ **Low Power**
 - Battery power for 8+ hours (laptops often last only 2 hours)
 - Limited cooling may limit power even if AC power available
- ◆ **Harsh environment**
 - Heat, vibration, shock
 - Power fluctuations, RF interference, lightning
 - Water, corrosion, physical abuse
- ◆ **Safety-critical operation**
 - Must function correctly
 - Must *not* function *incorrectly*
- ◆ **Extreme cost sensitivity**
 - \$.05 adds up over 1,000,000 units

Design constraints

- **Small Size and Low weight**
 - hand held electronics like scanners
 - Weight costs money
- **Low Power Consumption**
 - Battery operated devices must last long like laptops
 - Require more cooling
- **Harsh Environmental Conditions**
 - Heat, vibration, shock
 - Power fluctuations, RF interferences, lightning
 - Water corrosion, physical abuse

Design Constraints

- **Safety Critical Applications**
 - Must function correctly
 - Must not function incorrectly
- **Cost sensitivity**
 - Little cost variation may affect the sales

Design Challenges

- Does it really work?
 - Is the specification correct?
 - Does the implementation meet the spec?
 - How do we test for real-time characteristics?
 - How do we test on real data?
- How do we work on the system?
 - Observability, controllability?
 - What is our development platform?
- **More importantly – optimizing design metrics!!**

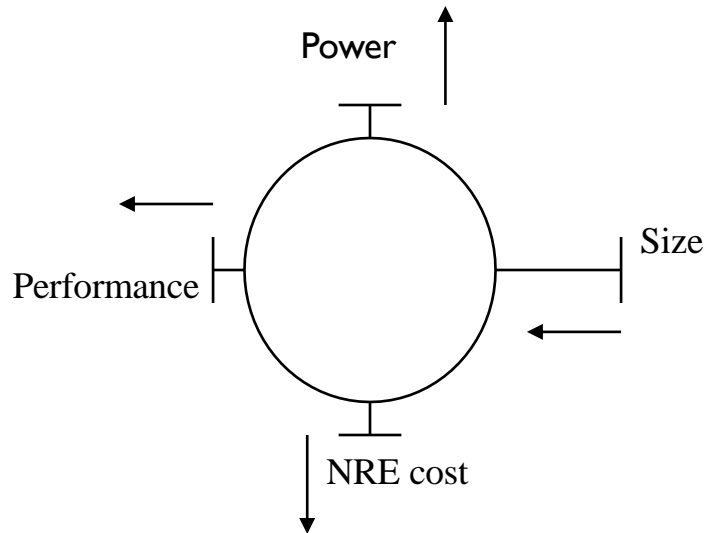
Design Metrics

- **Common metrics**
 - **Unit cost:** the monetary cost of manufacturing each copy of the system, excluding NRE cost
 - **NRE cost (Non-Recurring Engineering cost):**
The one-time monetary cost of designing the system
 - **Size:** the physical space required by the system
 - **Performance:** the execution time or throughput of the system
 - **Power:** the amount of power consumed by the system
 - **Flexibility:** the ability to change the functionality of the system without incurring heavy NRE cost

Design Metrics

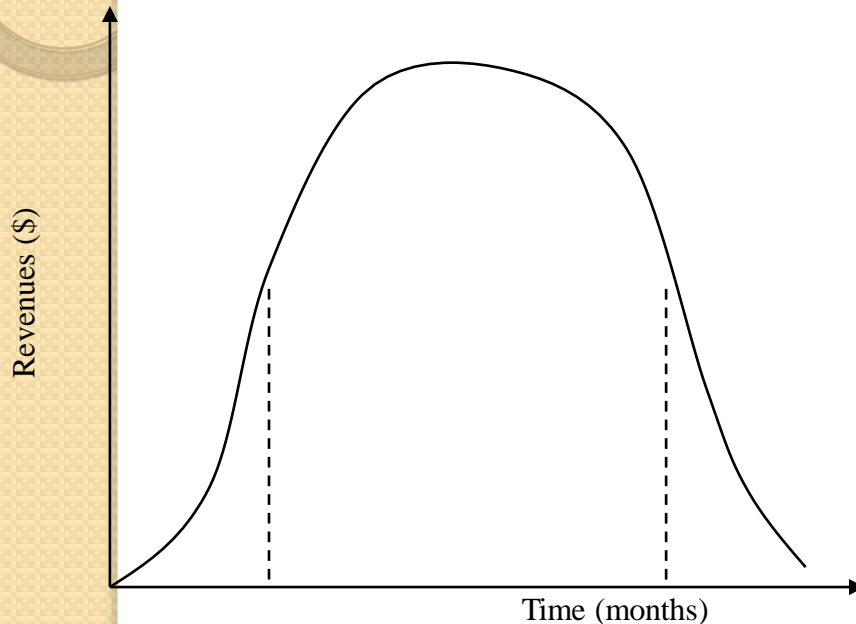
- **Common metrics (continued)**
 - **Time-to-prototype:** the time needed to build a working version of the system
 - **Time-to-market:** the time required to develop a system to the point that it can be released and sold to customers
 - **Maintainability:** the ability to modify the system after its initial release
 - **Correctness, safety, many more**

Trade-off in Design Metrics



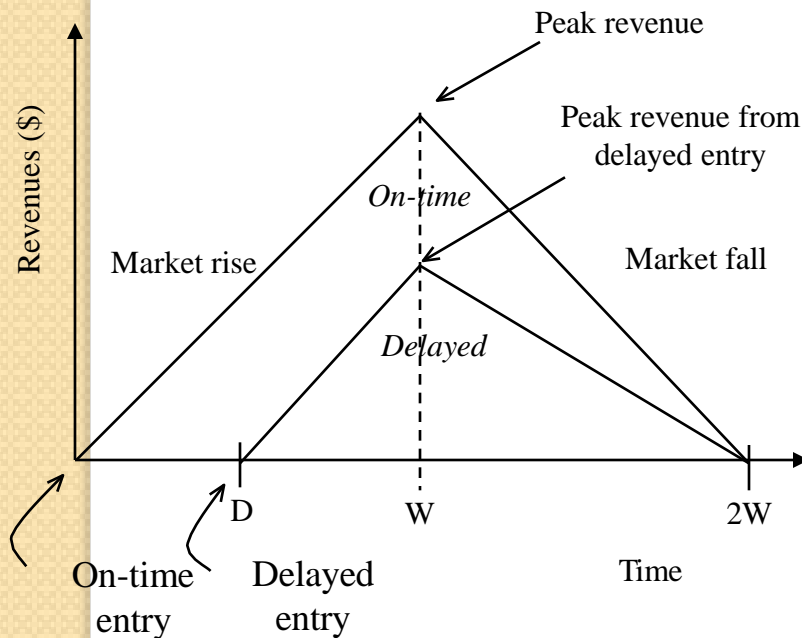
- Expertise with both **software and hardware** is needed to optimize design metrics
 - Not just a hardware or software expert, as is common
 - A designer must be comfortable with various technologies in order to choose the best for a given application and constraints

Time-to-market: a demanding design metric



- Time required to develop a product to the point it can be sold to customers
- Market window
 - Period during which the product would have highest sales
- Average time-to-market constraint is about 8 months
- Delays can be costly

Losses due to delayed market entry



- Simplified revenue model
 - Product life = $2W$, peak at W
 - Time of market entry defines a triangle, representing market penetration
 - Triangle area equals revenue
- Loss
 - The difference between the on-time and delayed triangle areas

Other Design Considerations

- **Dependability**

- **Reliability:** probability of system working correctly provided that it worked at time $t=0$
- **Maintainability:** probability of system working correctly d time units after error occurred. [Some systems require no maintenance throughout their operating lives (e.g. electric kettles, computer keyboards), while some may need it such as mobile phones and airplane flight control (software upgrade)]

Other Design Considerations

- Dependability
 - Availability: probability of system working at time t
 - Safety
 - Security

Basically, critical applications have to operate correctly at all time e.g. airplane flight control computer. This includes both **hardware and software** aspects.

References

- ❖ Embedded System Design,
 - ❖ By Frank Vahid / Tony Givargis
- ❖ Embedded System Black Book
 - ❖ by Dr.V. K.K. Prasad



Thanks