嵌入式系统设计方法

主要内容

- 嵌入式系统面临的挑战
- 嵌入式系统的设计过程
- 嵌入式系统设计方法学

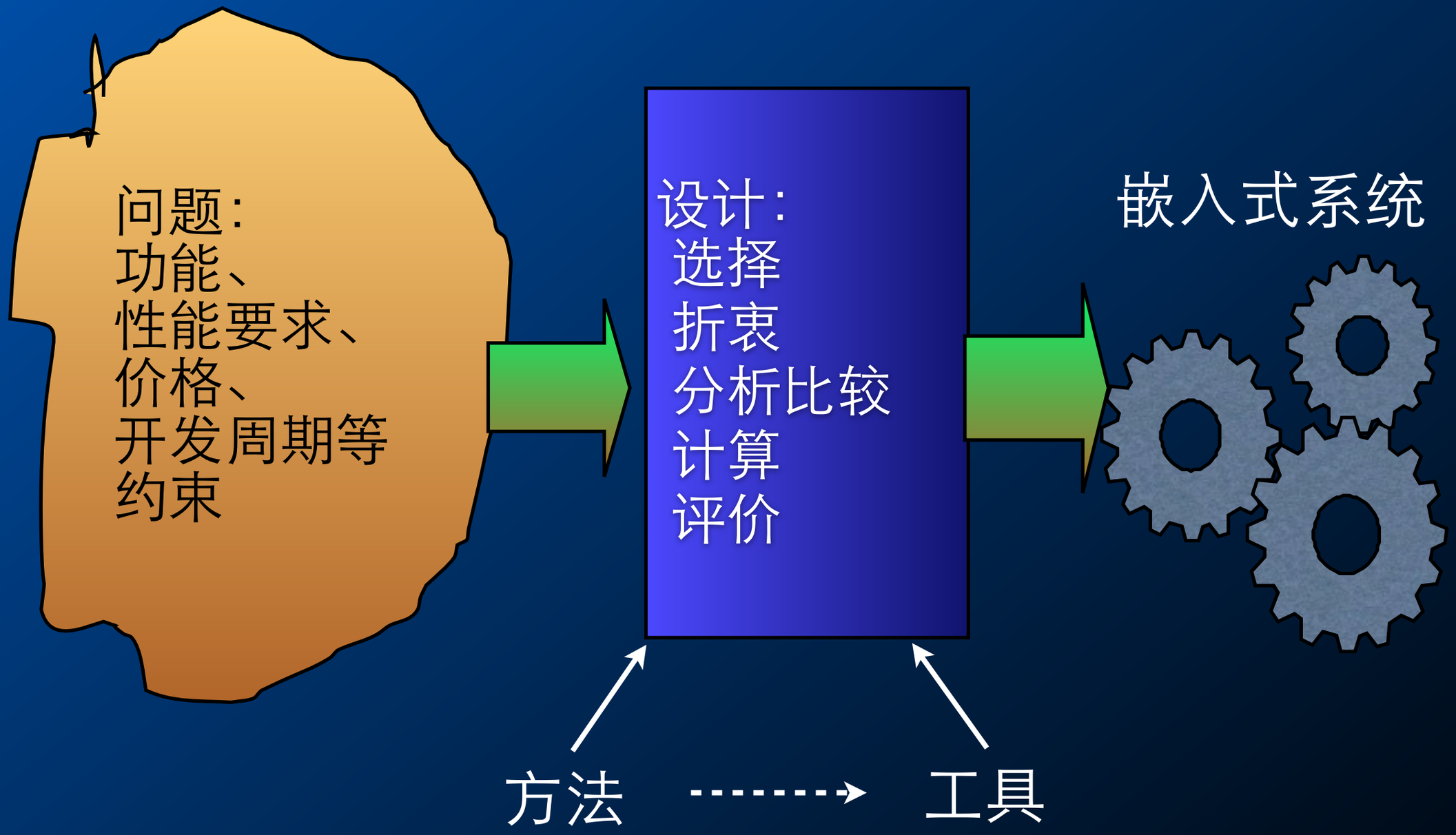
嵌入式系统设计所面临的挑战

- 需要多少硬件?
- 如何满足时限要求，如何处理多项功能在时间上的协调一致关系?
- 如何降低系统的功耗?
- 如何设计以保证系统可升级?
- 如何保证系统可靠地工作?

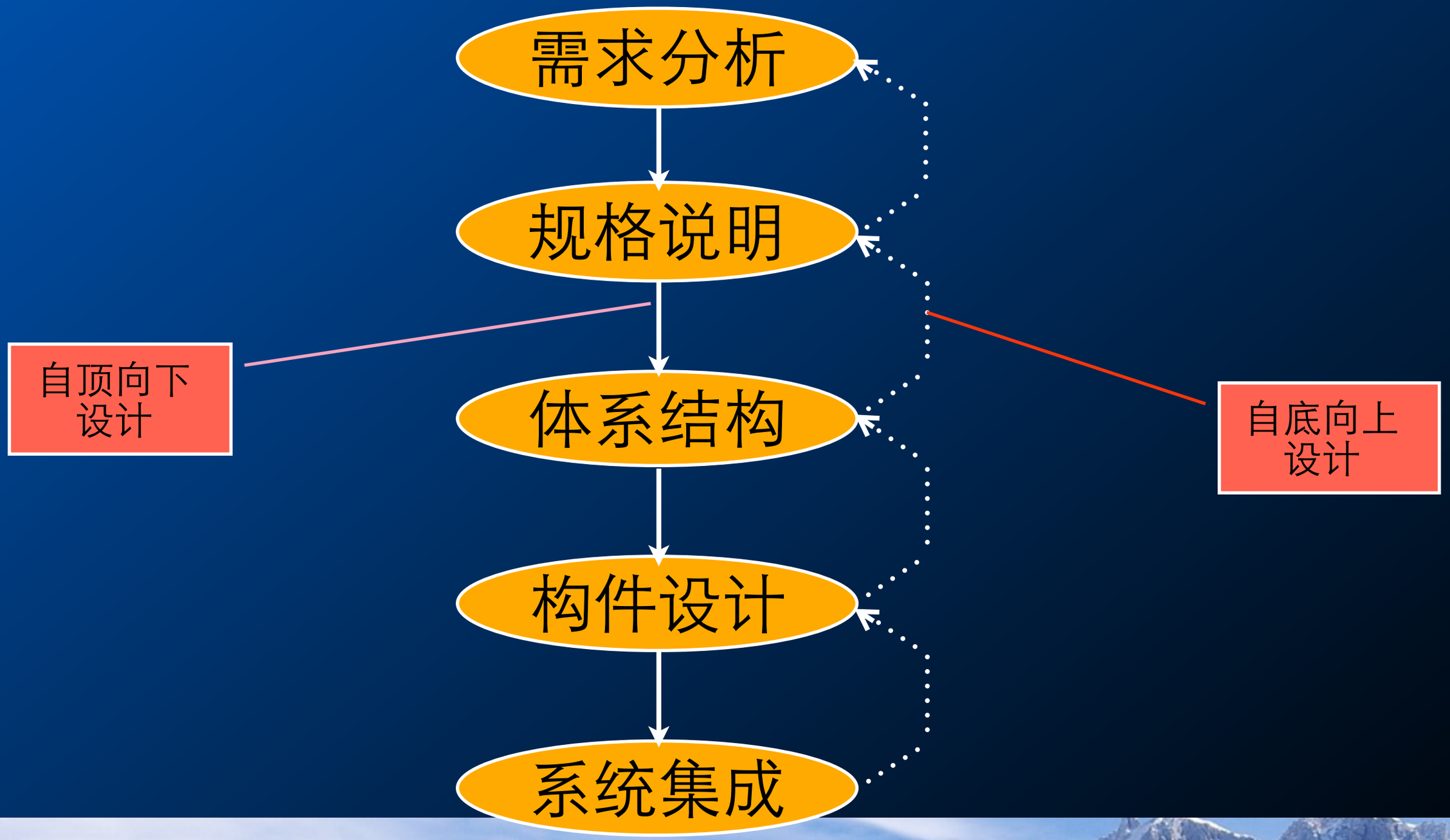
嵌入式系统设计者要求

- 懂得系统的整个构架
- 详细了解硬件的细节
- 软件设计满足：
  - 实时要求
  - 低功耗
  - 代码量小
- 详细了解领域知识

嵌入式系统的设计过程



嵌入式系统的设计过程的基本流程



需求分析

- Plain language description of what the user wants and expects to get.
- May be developed in several ways:
  - talking directly to customers;
  - talking to marketing representatives;
  - providing prototypes to users for comment.

Functional vs. non-functional requirements

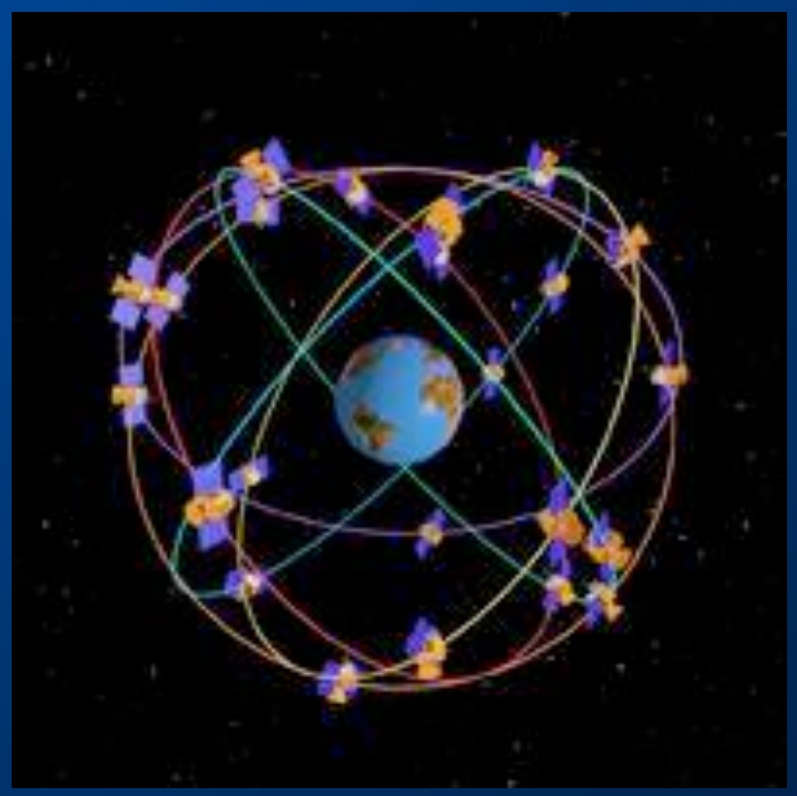
- Functional requirements:
  - output as a function of input.
- Non-functional requirements:
  - time required to compute output;
  - size, weight, etc.;
  - power consumption;
  - reliability;
  - etc.

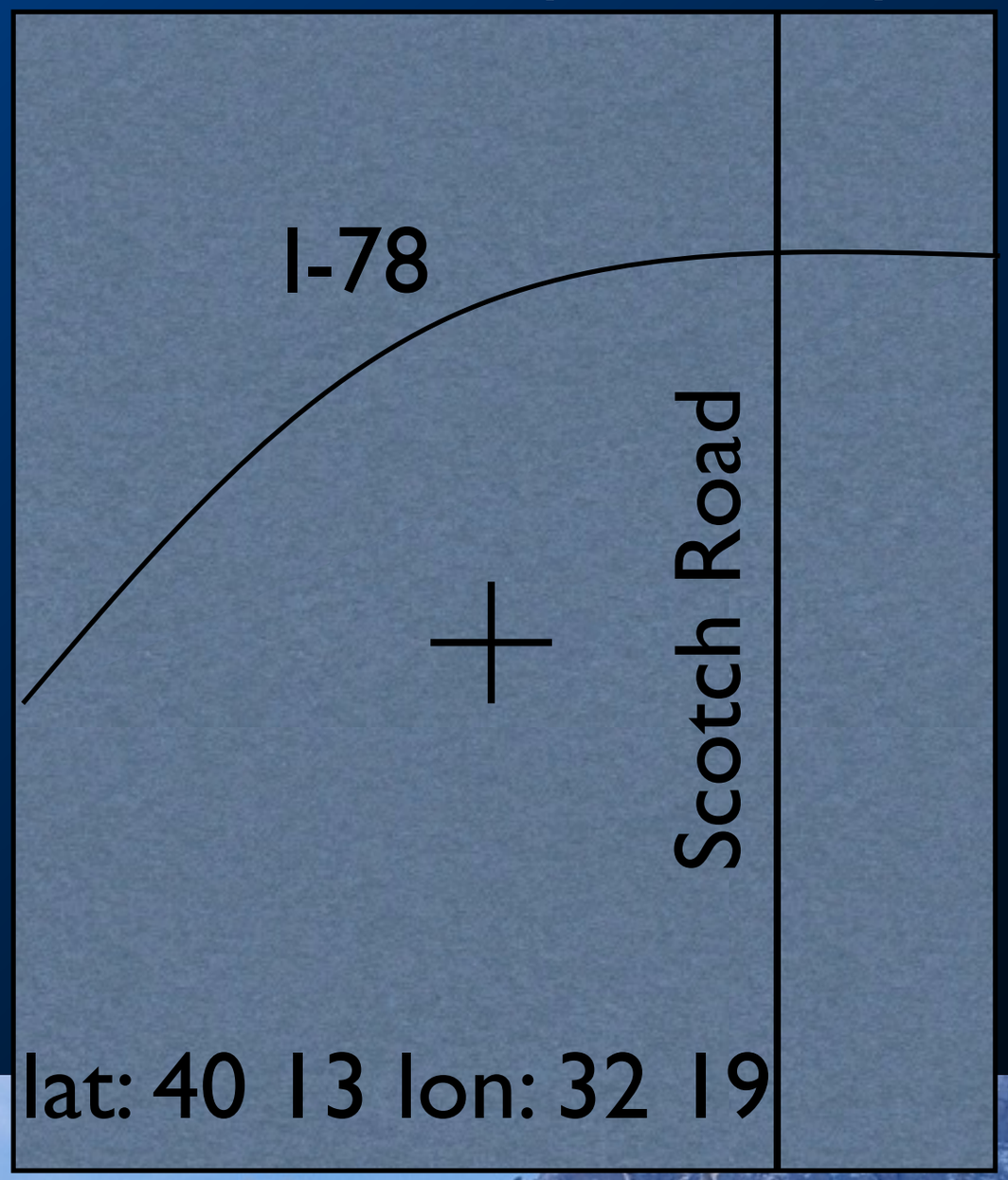
Our requirements form

name
purpose
inputs
outputs
functions
performance
manufacturing cost
power
physical size/weight

Example: GPS moving map requirements

- Moving map obtains position from GPS, paints map from local database.





GPS moving map needs

- Functionality: For automotive use. Show major roads and landmarks.
- User interface: At least 400 x 600 pixel screen. Three buttons max. Pop-up menu.
- Performance: Map should scroll smoothly. No more than 1 sec power-up. Lock onto GPS within 15 seconds.
- Cost: $500 street price = approx. $100 cost of goods sold.

GPS moving map needs, cont'd.

- Physical size/weight: Should fit in hand.
- Power consumption: Should run for 8 hours on four AA batteries.

GPS moving map requirements form

name	GPS moving map
purpose	consumer-grade moving map for driving
inputs	power button, two control buttons
outputs	back-lit LCD 400 X 600
functions	5-receiver GPS; three resolutions; displays current lat/lon
performance	updates screen within 0.25 sec of movement
manufacturing cost	$100 cost-of-goods-sold
power	100 mW
physical size/weight	no more than 2: X 6:, 12 oz.

Specification

- A more precise description of the system:
  - should not imply a particular architecture;
  - provides input to the architecture design process.
- May include functional and non-functional elements.
- May be executable or may be in mathematical form for proofs.

GPS specification

- Should include:
  - What is received from GPS;
  - map data;
  - user interface;
  - operations required to satisfy user requests;
  - background operations needed to keep the system running.

体系结构设计

- What major components go satisfying the specification?
- Hardware components:
  - CPUs, peripherals, etc.
- Software components:
  - major programs and their operations.
- Must take into account functional and non-functional specifications.

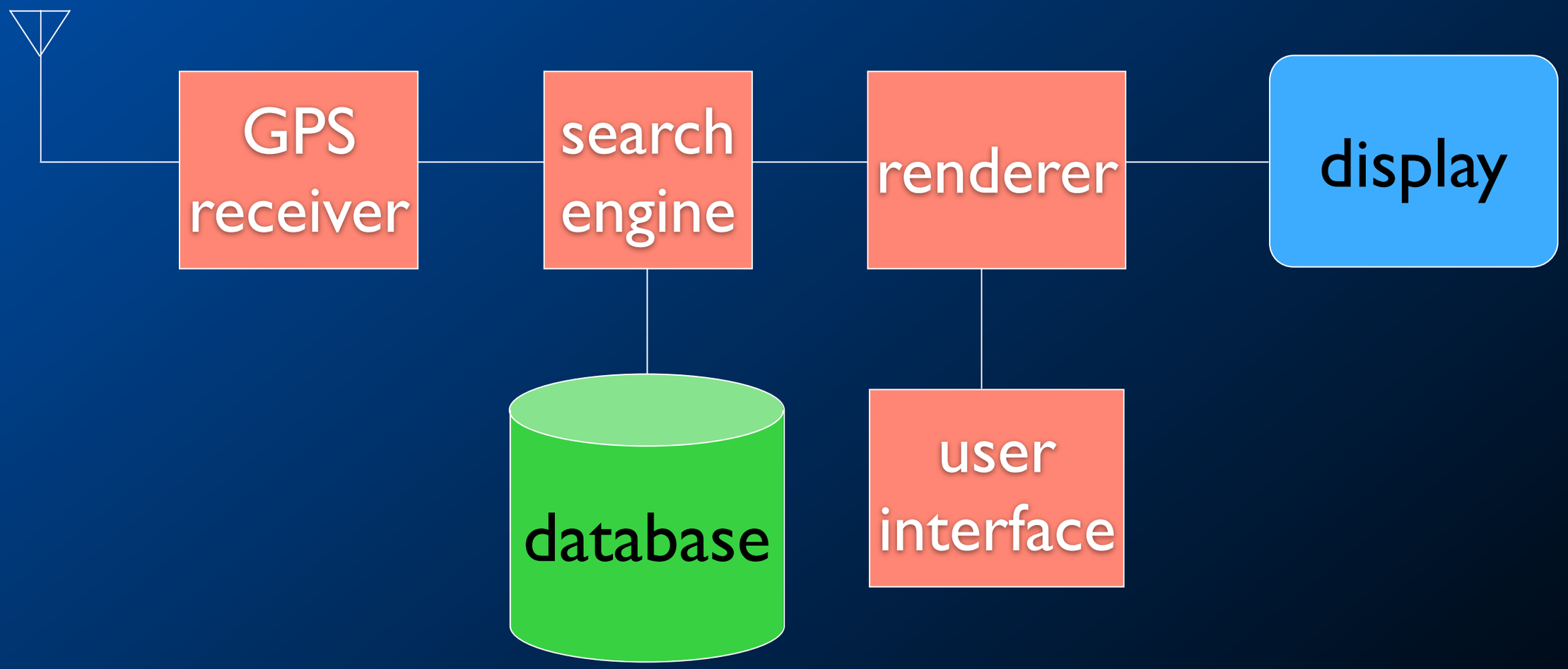
Designing hardware and software components

- Must spend time architecting the system before you start coding.
- Some components are ready-made, some can be modified from existing designs, others must be designed from scratch.

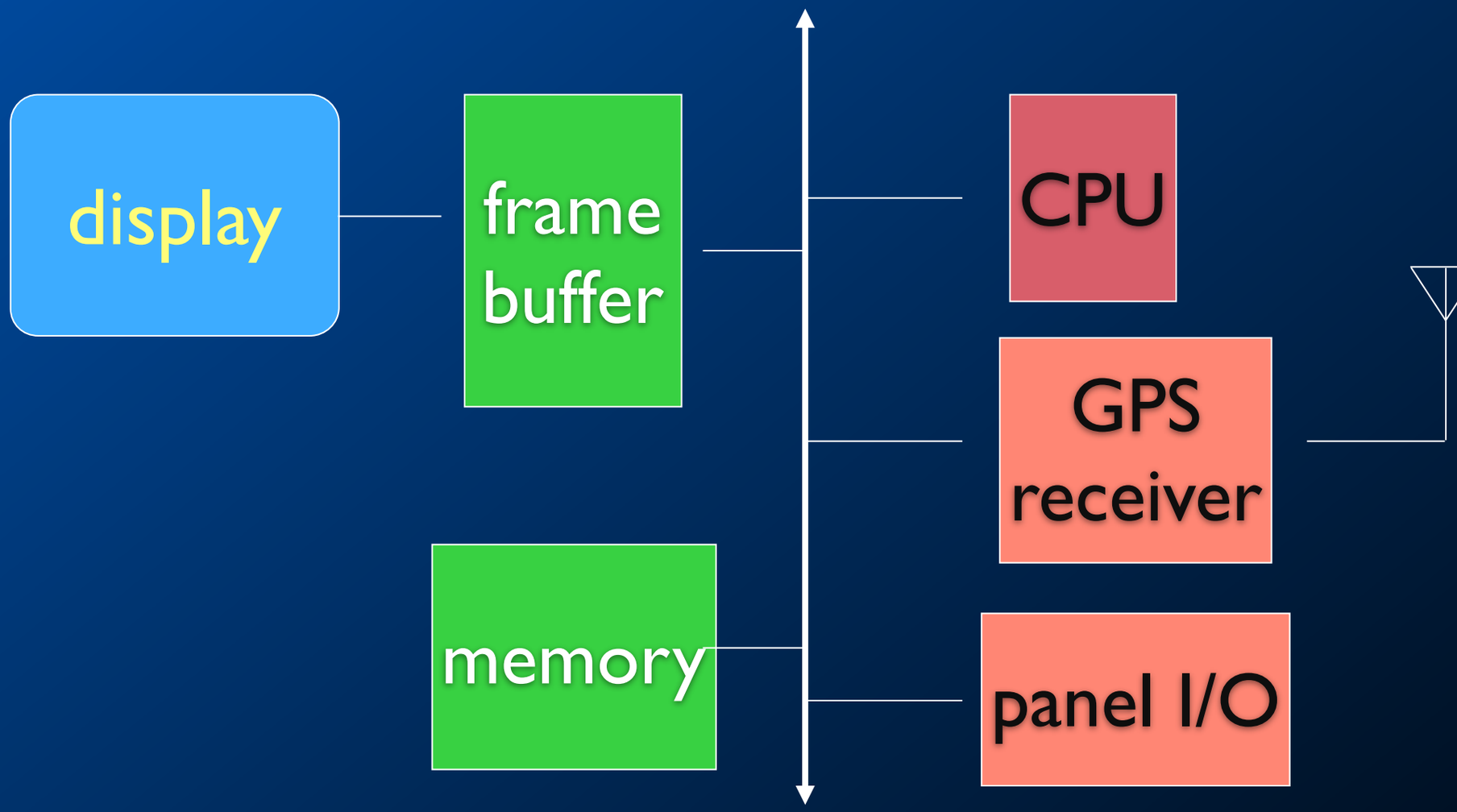
系统结构设计

- 系统如何实现设计说明书描述的功能
- 基于组件的系统结构
- 软件/硬件划分
  - 嵌入式系统中软件和硬件协同完成系统的功能
  - 软件硬件划分通常由速度、灵活性以及开销来决策

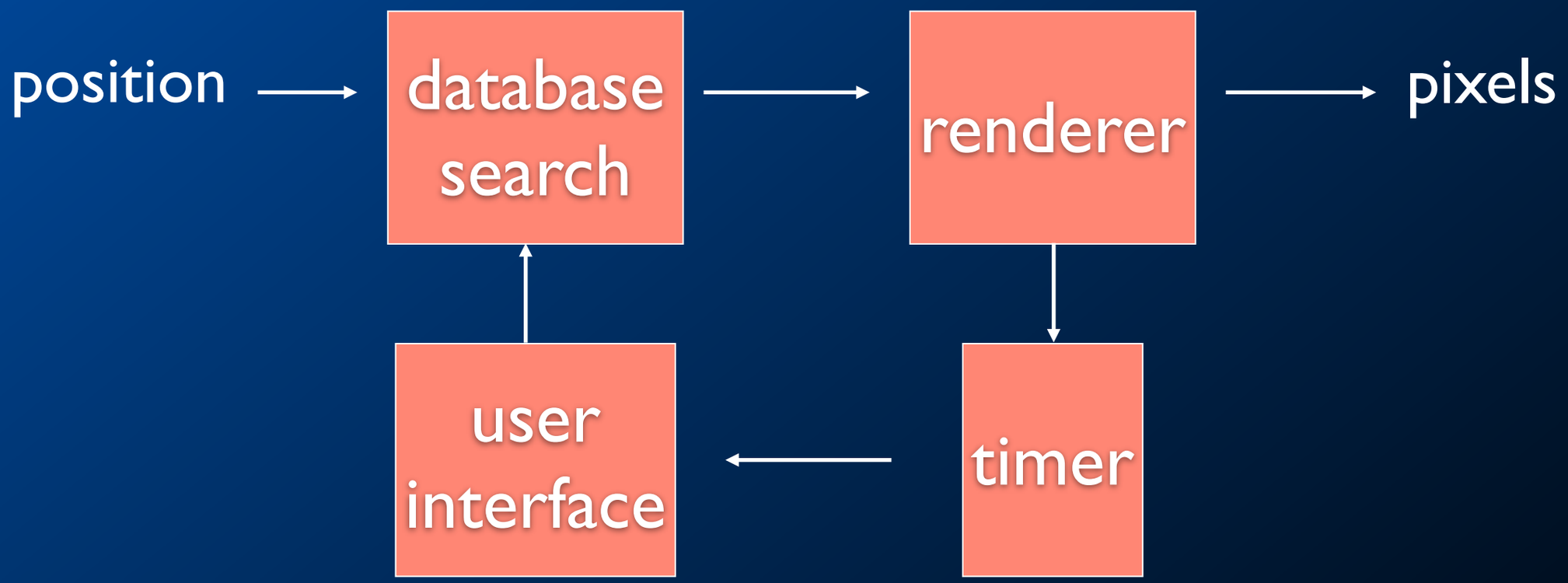
GPS moving map block diagram



GPS moving map hardware architecture



GPS moving map software architecture



软硬件的划分

- 嵌入式系统的设计涉及硬件与软件部件，设计中必须决定什么功能由硬件实现，什么功能由软件实现。
- 硬件和软件具有双重性
- 软硬件变动对系统的决策造成影响
- 划分和选择需要考虑多种因素
- 硬件和软件的双重性是划分决策的前提

通常由软件实现的部分

- 操作系统功能
  - 任务调度
  - 资源管理
  - 设备驱动
- 协议栈
  - TCP／IP
- 应用软件框架
- 除基本系统、物理接口、基本逻辑电路，许多由硬件实现的功能都可以由软件实现。

双重性部分

- 算法
  - 加密／解密
  - 编码／解码
  - 压缩／解压
  - ……
- 数学运算
  - 浮点运算， FFT， ……
  - ……

软硬件技术对系统结构的影响

- 硬软件设计的趋势——融合、渗透
  - 硬件设计的软件化
    - VHDL,Verilog
    - HANDL-C
    - 软件实现的硬件化
      - 各种算法的ASIC
- 对系统设计的影响——协同设计
  - 增加灵活性
  - 增加了风险

系统集成与测试

- Put together the components.
  - Many bugs appear only at this stage.
- Have a plan for integrating components to uncover bugs quickly, test as much functionality as early as possible.

嵌入式系统设计方法学

嵌入式系统设计方法的演变

1

以PCB、CAD和在线仿真器为主要工具

2

EDA和EOS为开发平台

3

以IP内核库为设计基础，用软硬件协同设计技术的系统级设计方法

传统的嵌入式系统设计过程

- 传统软硬件设计过程的基本特征:
  - 系统在一开始就被划分为软件和硬件两大部分
  - 软件和硬件独立进行开发设计
  - “Hardware first” approach often adopted
- 隐含的一些问题:
  - 软硬件之间的交互受到很大限制
    - 凭经验划分软硬件
    - 软硬件之间的相互性能影响很难评估
  - 系统集成相对滞后，NRE较大
- 因此:
  - Poor quality designs（设计质量差）
  - Costly modifications（设计修改难）
  - Schedule slippages（研制周期不能有效保障）

HW/SW Co-design

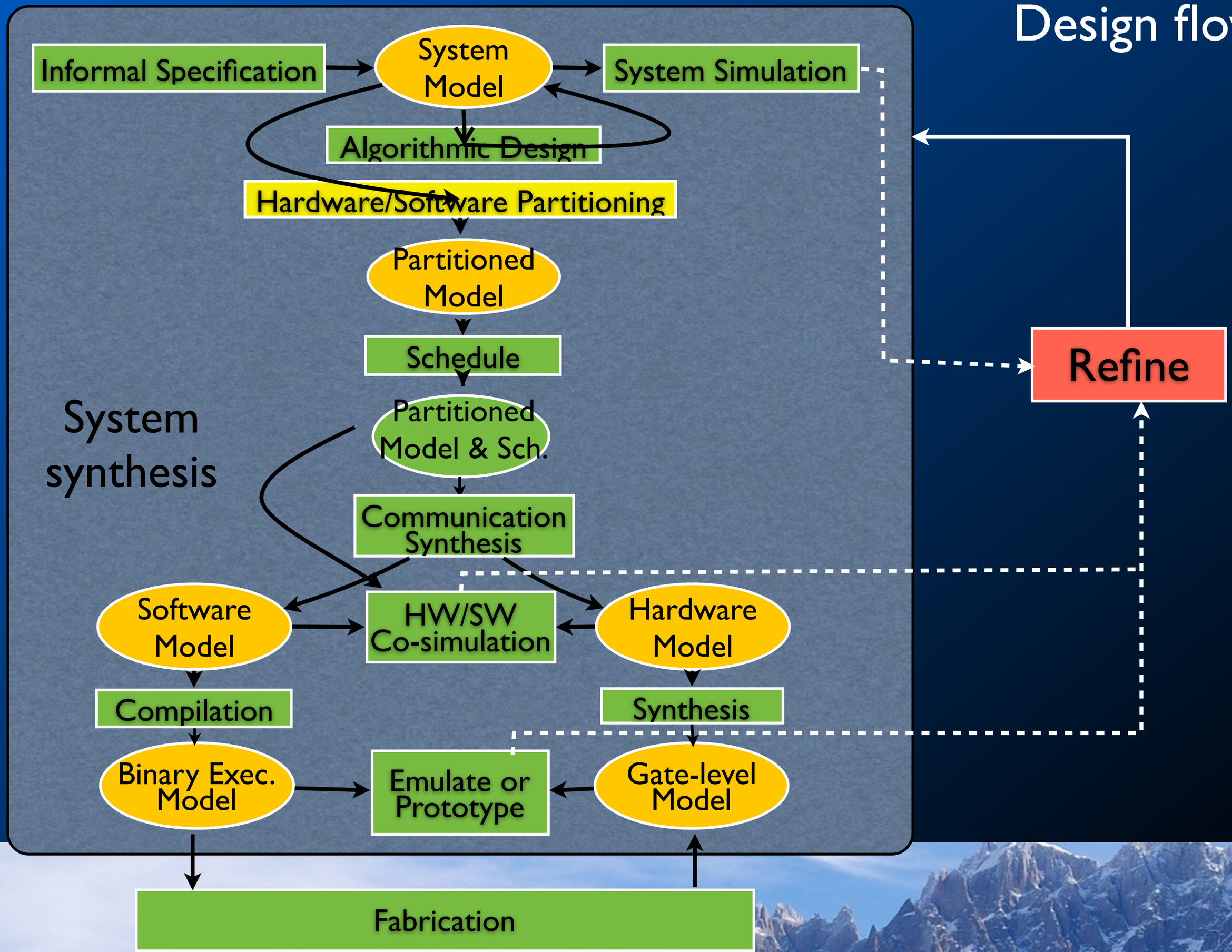
- HW/SW Co-design means the design of a special-purpose system composed of a few application-specific ICs that cooperate with software procedures on general-purpose processors (1994)
- HW/SW Co-design means meeting system-level objectives by exploiting the synergism of hardware and software through their concurrent design (1997)
- HW/SW Co-design tries to increase the predictability of embedded system design by providing analysis methods that tell designers if a system meets its performance, power, and size goals and synthesis methods that let designers rapidly evaluate many potential design methodologies (2003)
- It moved from an emerging discipline (early '90s) to a mainstream technology (today)

Simplified design flow: part in HW, part in SW

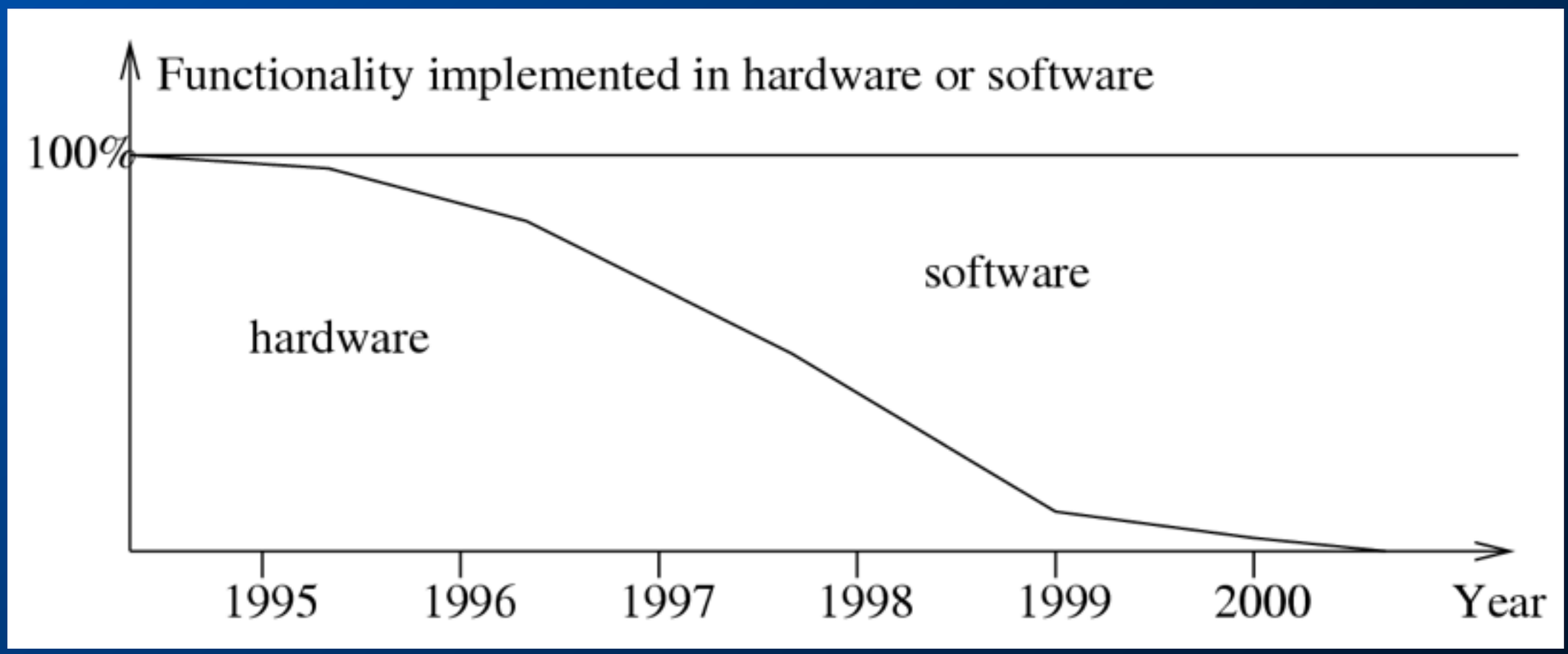
Decision based on hardware/ software partitioning, a special case of hardware/software co-design.

HW/SW Co-design
- Task concurrency management
- High-level transformations
- Design space exploration
- HW/SW partitioning
- Compilation, scheduling

Design flow


Informal Specification
System Model
System Simulation
Algorithmic Design
Hardware/Software Partitioning
Partitioned Model
Schedule
Partitioned Model & Sch.
Communication Synthesis
System synthesis
Software Model
HW/SW Co-simulation
Hardware Model
Compilation
Synthesis
Binary Exec. Model
Emulate or Prototype
Gate-level Model
Refine
Fabrication

Hardware/Software Partitioning



- No need to consider special purpose hardware in the long run?
- Specialized hardware needed for
  - Low power operation
  - High performance
- Increasing application complexity
  - "By the time MPEG-n can be implemented in software, MPEG-n+1 has been invented" [de Man]

Design objectives

- Cost
- Performance
- Power
- Area
- Scalability and reusability
- Fault tolerance
- Thermal characteristics
- …

Thank you!