IMPORTANT NOTICE TO STUDENTS

These slides are **NOT** to be used as a replacement for student notes.
These **slides** are sometimes **vague and incomplete on purpose** to spark a class discussion

Conceptual, Concrete & Reference Architecture

"Linux Case Study"

"A Reference Architecture for Web Servers"

CS 446/646 ECE452
May 27th, 2011

WATERLOO
CHERITON SCHOOL OF COMPUTER SCIENCE

Conceptual Architecture

Intent

- " *direct attention at an **appropriate decomposition** of the system **without** delving into the **details** of interface specification*"[1]
- appropriate decomposition
  - focus on key constructs & abstractions
    rather than on technical/implementation details

[1] R. Malan, D. Bredemeyer, Software Architecture Action Guide.

Conceptual Architecture

Includes

- what a system does (requirements / functionality)
- identification of significant components & connectors
  - component responsibilities
  - component interactions
  - control & data flow
- identification of architectural (non-functional) concerns
  - e.g. security
  - other crosscutting concerns

Conceptual Architecture

Provides

- communicating architectural details with
  - stakeholders (technical & non-technical)

Input artifacts

- reference architecture (more on this later)
- requirements (functional & non-functional)
- documentation & code
  - Hmm...these two seem out of place?

Conceptual Architecture

Activities

- capture system functionality
  - requirements to use case descriptions
- capture system properties
  - evolution, system load, portability
- capture system constraints
  - legacy components, third party components
  - resources, time
  - technical capabilities

Concrete Architecture

Intent

- implementation specific architecture
  - decomposition into (implementation specific components)
  - identification of actual relationships
- actual
  - e.g. identify third party, COTS components

Concrete Architecture

Includes

- what a system does (requirements / functionality)
- **how will it do it**
- identification of significant components & connectors
  - component responsibilities
  - component interactions
  - control & data flow
- realization of architectural non-functional concerns

Concrete Architecture

Input Artifacts

- ask the class
- can we extract concrete architecture from code
  - isn't that reveres engineering?
  - choice of tools

Example

Linux

- lack of formal architecture
  - conceptual or concrete
- considerable code size
- fragmented documentation
  - individual systems well defined but not the overall
- based on
  - Linux as a Case Study: Its Extracted Software Architecture, Ivan T. Bowman, Richard C. Holt, Neil V. Brewster, 2005

Example

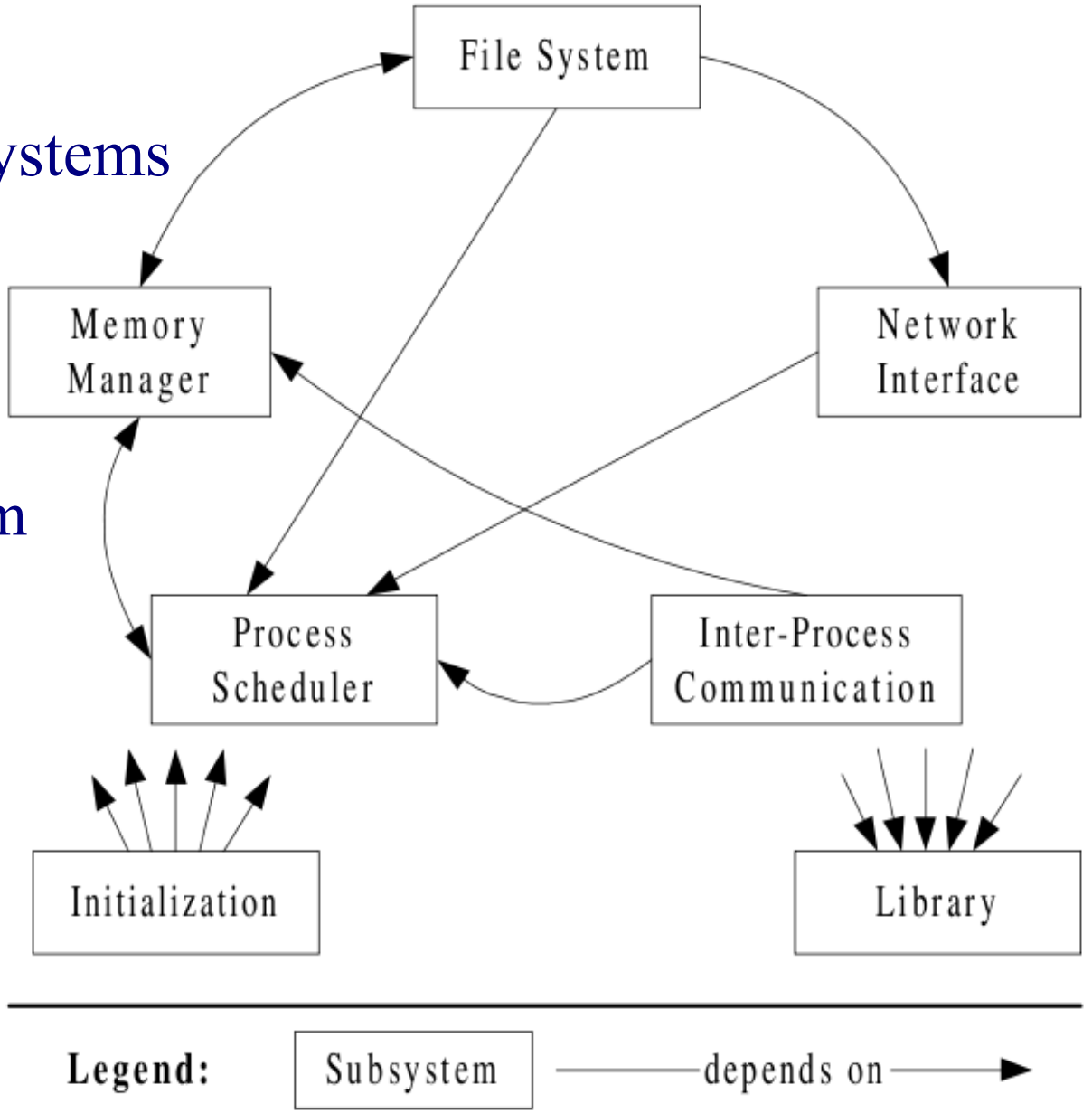
Linux Conceptual Architecture

- input artifacts
  - Unix & Minix descriptions
  - Linux documentation

Linux Conceptual Architecture

Observations

- seven kernel sub-systems
- dependencies
  - initialization depends on all
  - library sub system forms the core

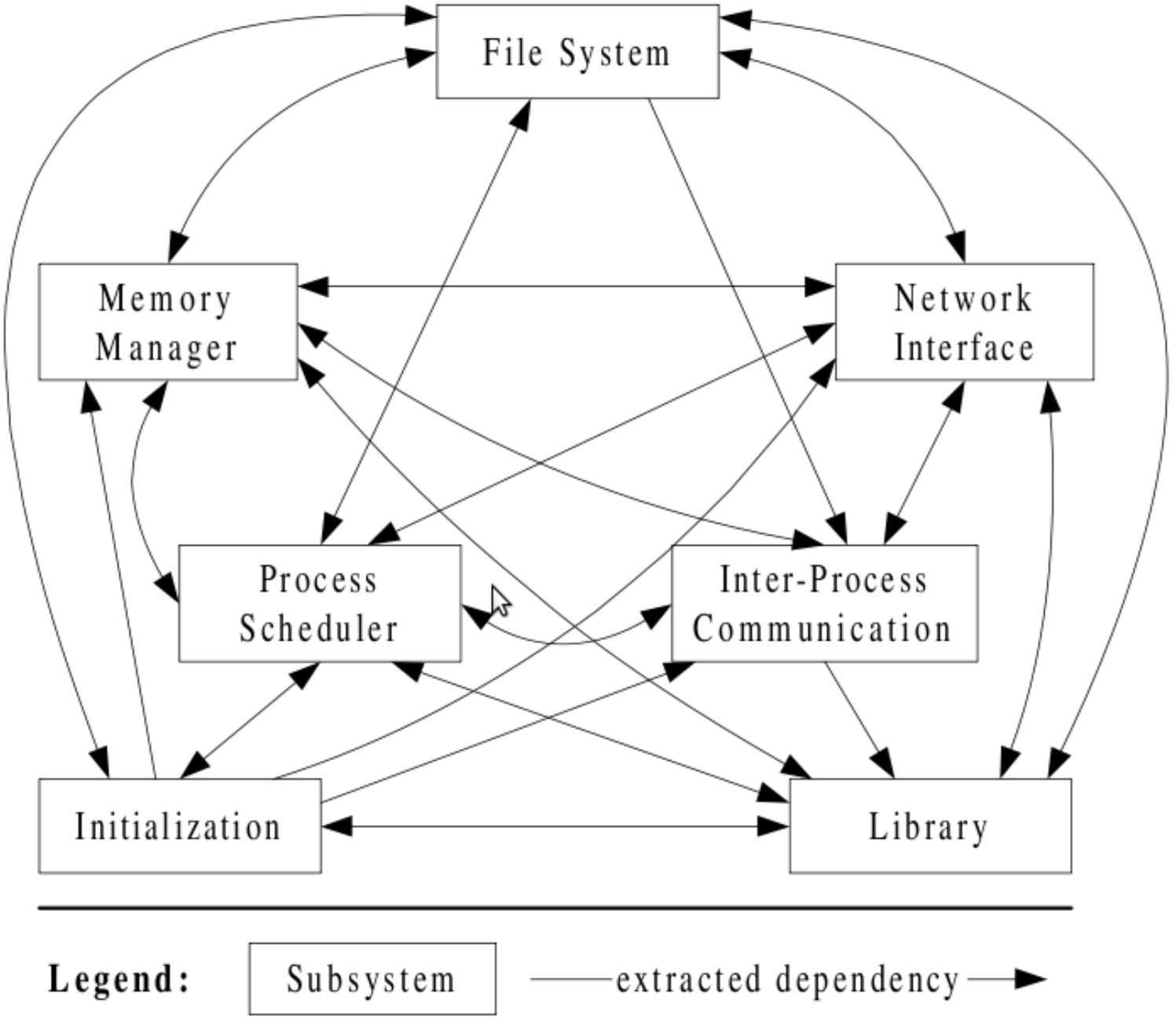


Linux Concrete Architecture

General technique

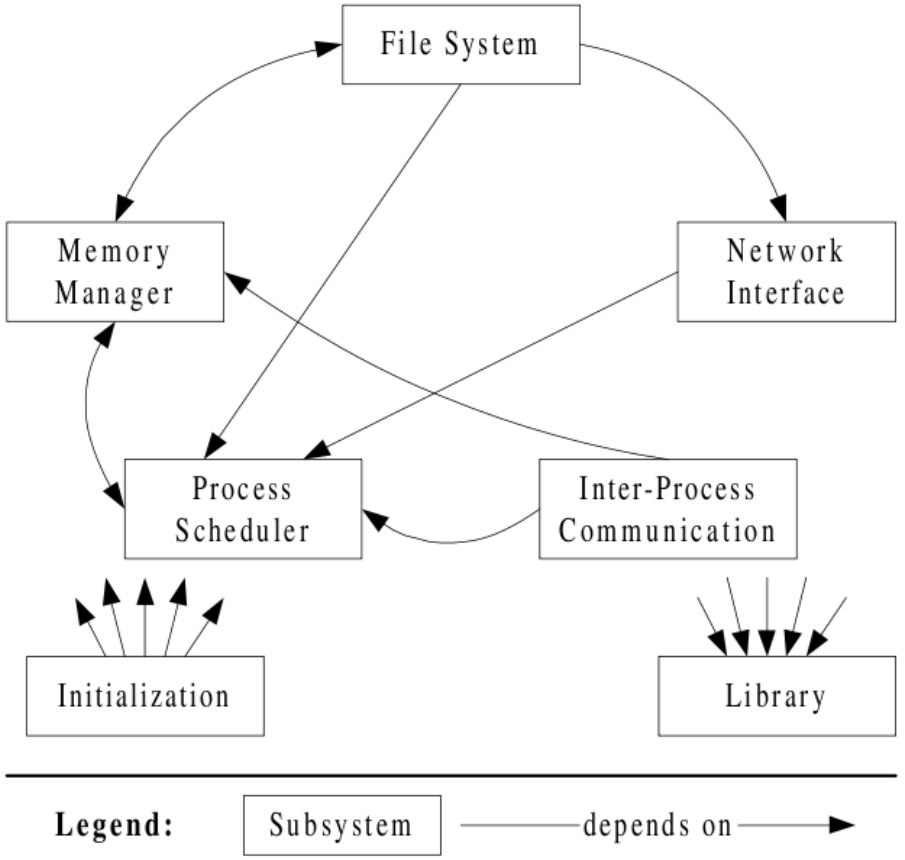
- inspection
  - source (directory structures, packages, file naming etc)
  - compiled artifacts
- clustering
  - grouping of components
- discovery
  - inter-component dependency

Linux Concrete Architecture

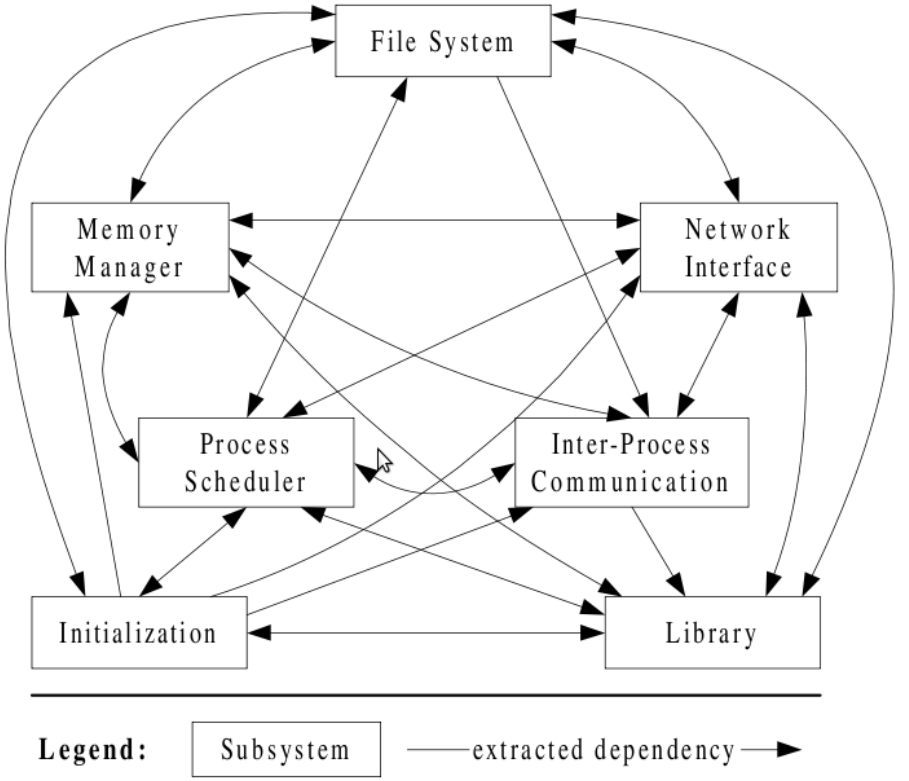


Comparison

Conceptual Architecture



Concrete Architecture



Observations

Structural

- same subsystem decomposition
  - despite different input artifacts

Dependency Relationships

- higher than expected inter-component dependency found
- why would this be?
  - *"avoided existing interfaces for better efficiency"*

Architectural Drift & Erosion

Architectural erosion

- *conceptual architectural violations*

Architectural drift

- *concrete architecture shifts away from conceptual architecture*

Reference Architecture

Definitions

- *"A reference architecture for a **domain** defines the **fundamental components** of the **domain** and the **relations** between them"*

- *"A reference architecture for a **domain** is an architectural template for all the software systems in the domain"*

Example 1

Automobile

- attributes
  - transportation
  - wheels
  - steering
  - speed / gears

Is This an Automobile?

But this meets the attribute list

Properties

Domain

- what is a domain?
- reference architecture covers a whole domain

Fundamental components

- universal abstractions
  - applicable across the domain
- interaction of these abstractions

Template

- a *product* architecture is an instantiation of the reference

Properties

Availability

- well known for mature domain
  - compilers, operating systems
- absent for new domains
  - web servers

Benefits

Documentation

- captures the main ideas and components across domain
- provides a higher level abstraction for architecture itself
  - we don't have to reinvent the wheel or the architecture

Communication

- provides a common vocabulary
  - the *wheel* is too big
  - *braking* distance of the car is reasonable
  - 0 to 60 in 10 seconds

Benefits

Evaluation

- aids in the comparison of the different product architectures in the same domain
  - electric vs. hybrid
  - sedan vs. coupe

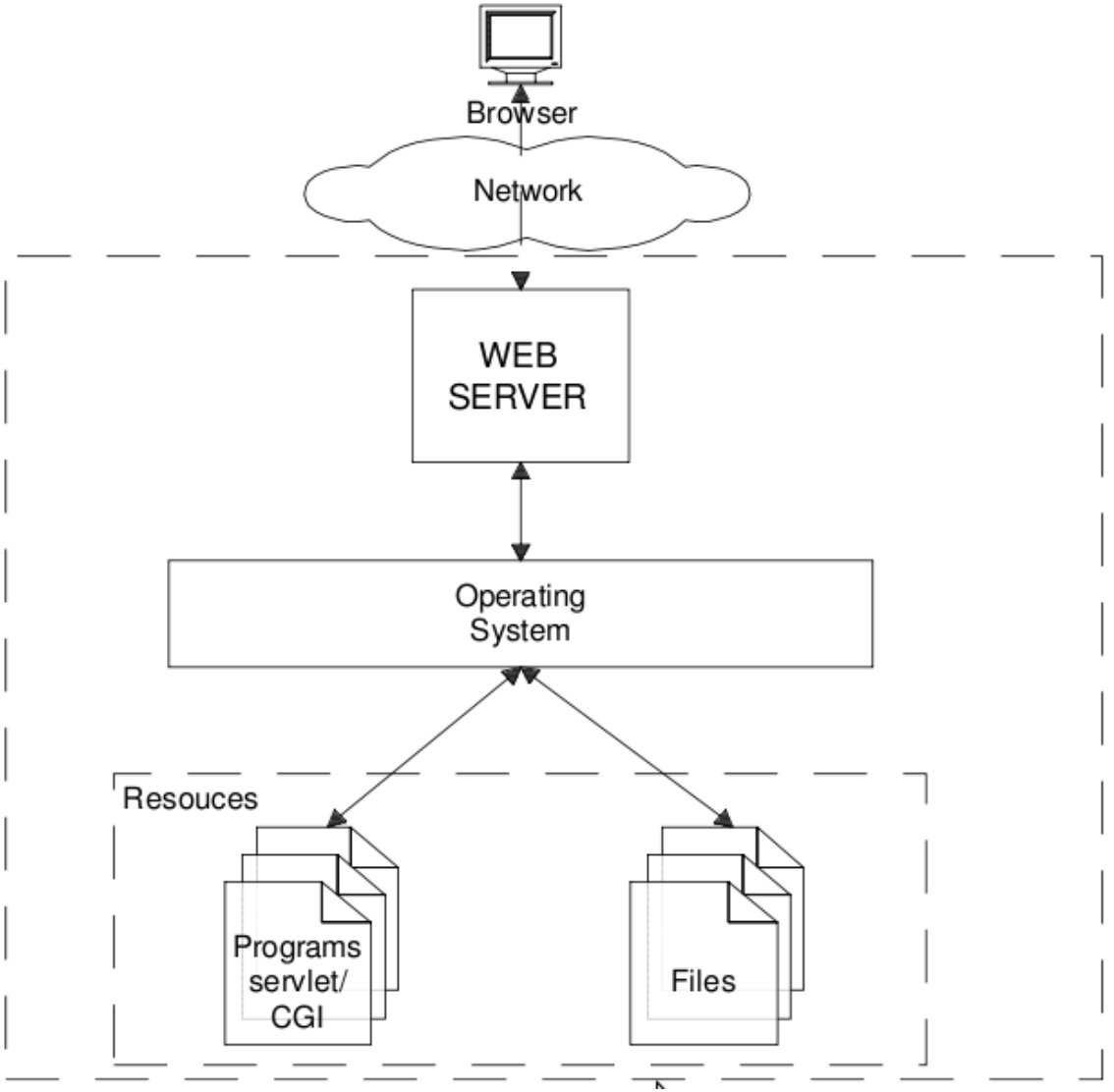
Web Server Reference Architecture

Domain:

- web servers, application servers

Web servers

- Apache
- AOL Server
- Jigsaw



Summary of Web Servers

Web Server	Dev Type	1st Release	Code Size (KLOC)	Impl	Arch stable for (years)
Apache	Open source	April 1995	80	C	5
AOL Server	Commercial	May 1995	164	C & TCL	-
Jigsaw	Educational	May 1996	106	Java	2.5

Deriving Reference Architecture

Process

- step1: derive a conceptual architecture for each
  - **propose** a conceptual architecture
    - using domain knowledge and available documentation
  - **refine** the conceptual architecture
    - using the concrete architecture
  - Q: did we not say that a reference architecture should be an input artifact to a conceptual architecture?

Deriving Reference Architecture

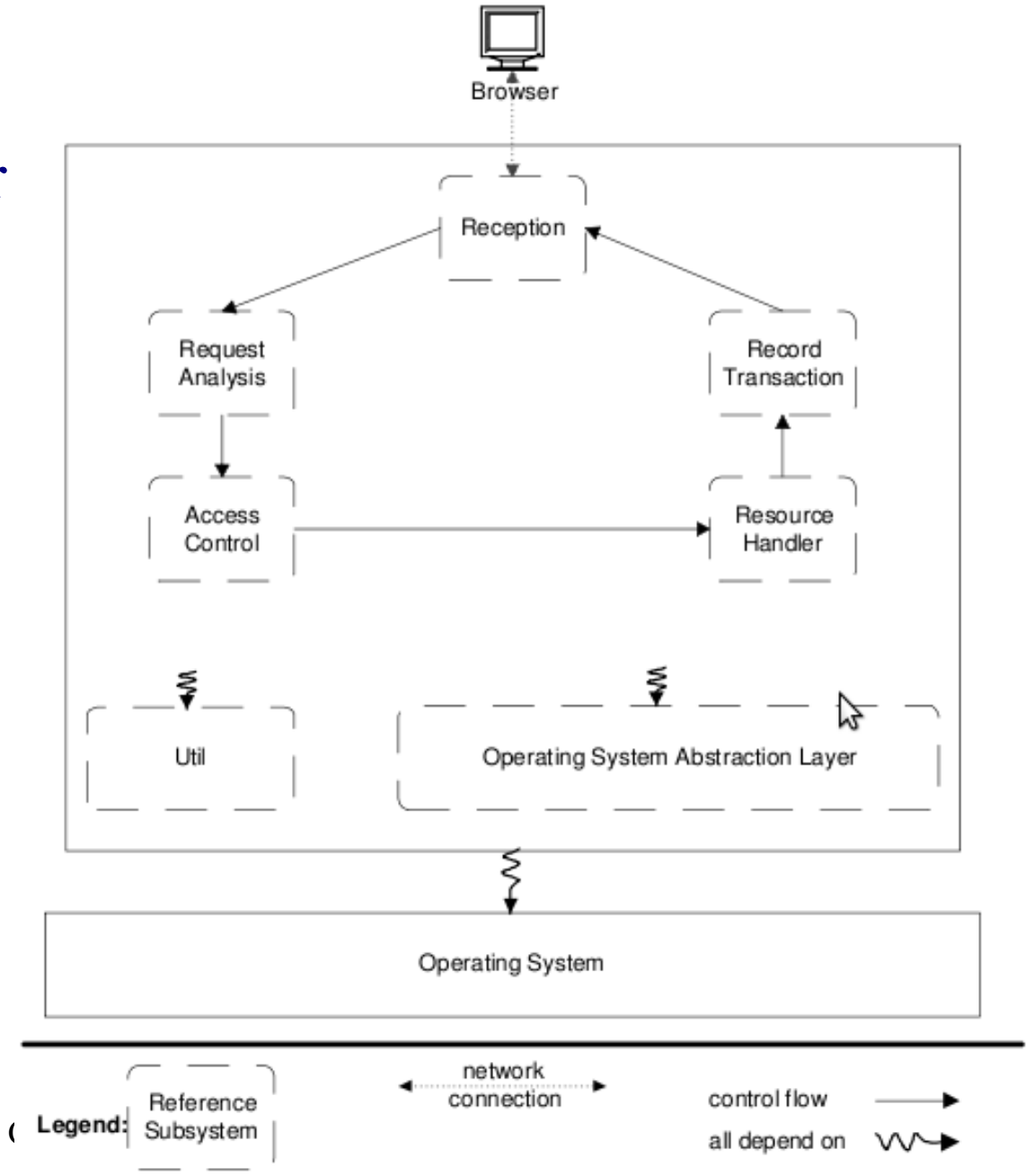
Process

- step2: derive a reference architecture from step 1
  - **propose** a reference architecture based on
    - domain knowledge
    - common structure between the conceptual architecture
  - **refine** the reference architecture
    - using the conceptual architecture (from step 1)

Web Server Reference Architecture

Architectural Style

- follows pipes & filter architectural style
  - hmmm.... does it really?
  - what other architectural styles better define web servers?



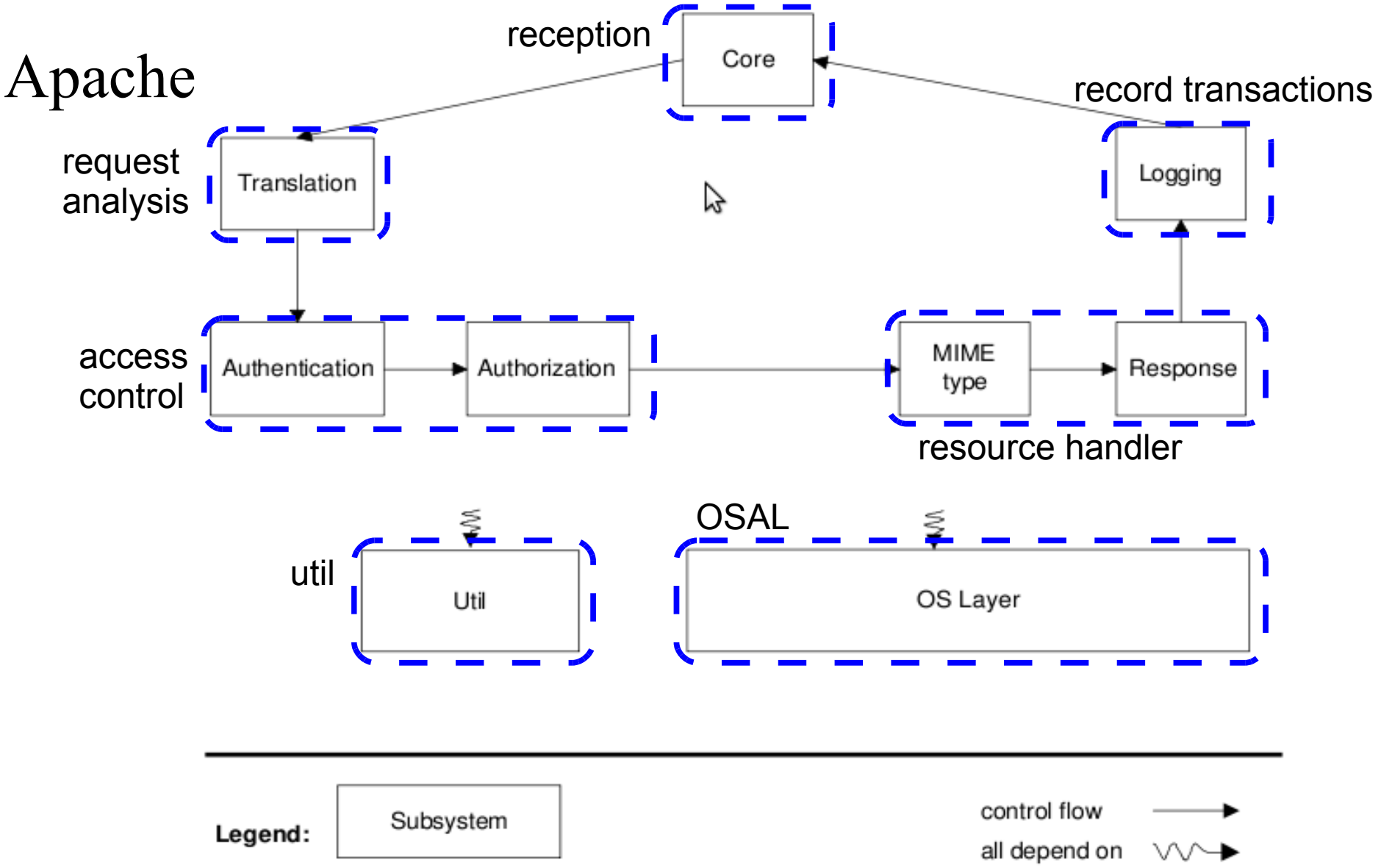
Flexibility of Reference Architecture

Intent

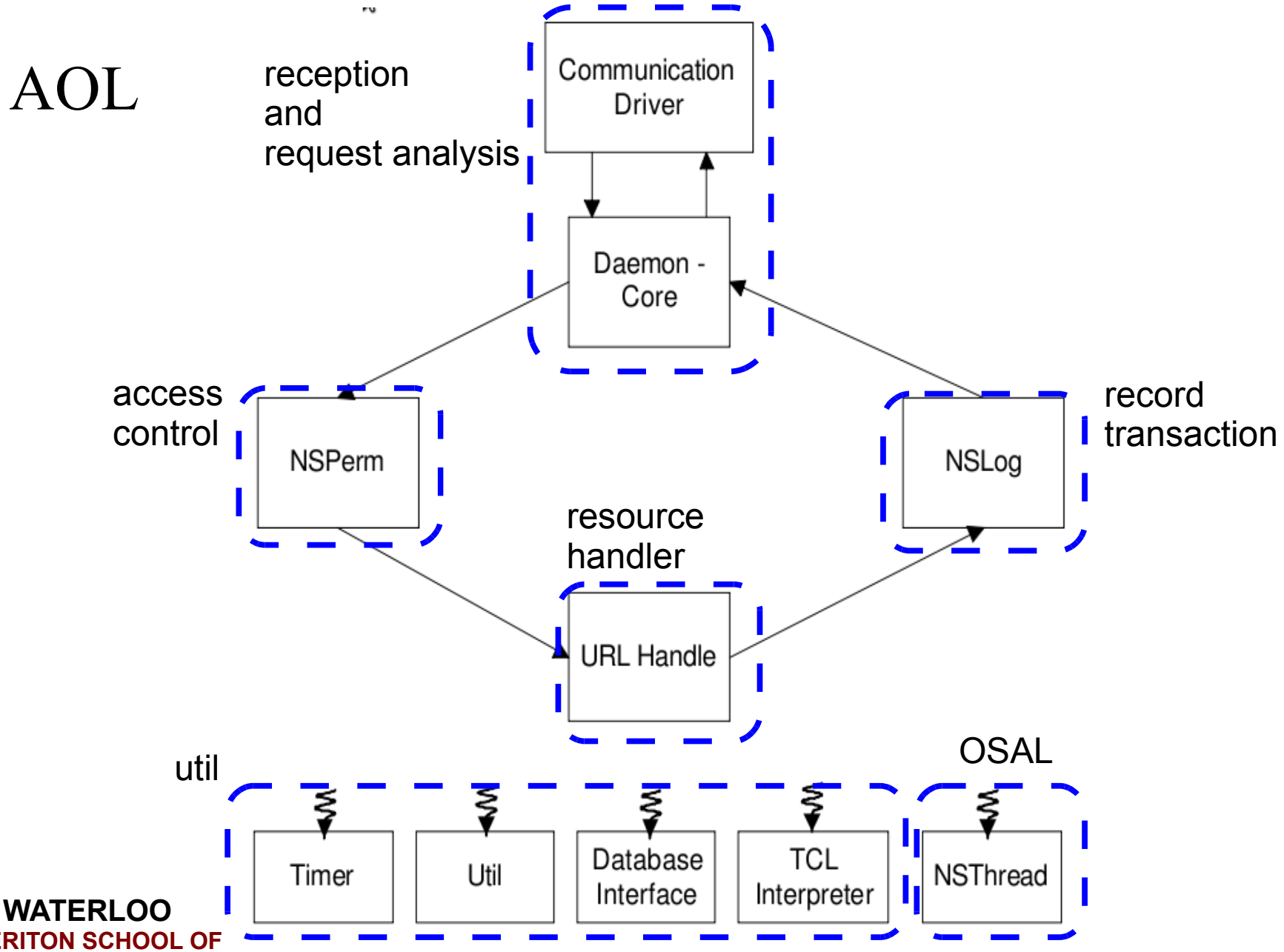
- *"To be useful a reference architecture must be **flexible** enough to **encompass** **many** product **architectures**"*

- what does flexibility mean?
  - security flexibility?
  - concurrency flexibility?

Reference & Conceptual Mapped



Reference & Conceptual Mapped



Observations

Structural

- subsystem **organization** is the main difference and not the subsystem **responsibility**
- reference architecture is abstract
  - does not depend on
    - development methodology
    - platform
    - implementation concerns