Material and some slide content from:
- Emerson Murphy-Hill
- Software Architecture: Foundations, Theory, and Practice
- Essential Software Architecture

Architectural Styles

Reid Holmes

Lecture 5 - Tuesday, September 28 2010.

Objectives

- What are the benefits / pitfalls of different architectural approaches?
- What are the phases of the design process?
- What are some alternative design strategies? When are they necessary?
- Define: abstraction, reification, and SoC
- Identify key architectural style categories

Architectural approaches

- Creative
  - Engaging
  - Potentially unnecessary
  - Dangerous
- Methodical
  - Efficient when domain is familiar
  - Predictable outcome
  - Not always successful

Design process

1. Feasibility stage:
   - Identify set of feasible concepts
2. Preliminary design stage:
   - Select and develop best concept
3. Detailed design stage:
   - Develop engineering descriptions of concept
4. Planning stage:
   - Evaluate / alter concept to fit requirements, also team allocation / budgeting

Design strategies

- Standard
- Cyclic
  - Revisit earlier stages
- Parallel
  - Split off #2 or #1 in parallel
- Adaptive
  - Plan next stage with insights from current
- Incremental
  - Update all stages as experience is gained

Abstraction

Definition:

> “A concept or idea not associated with a specific instance”

Top down

> Specify ‘down’ to details from concepts

Bottom up

> Generalize ‘up’ to concepts from details

Reification:

> “The conversion of a concept into a thing”

Level of discourse

- Consider application as a whole
  - e.g., stepwise refinement
- Start with sub-problems
  - Combine solutions as they are ready
- Start with level above desired application
  - e.g., consider simple input as general parsing

Separation of Concerns

- Decomposition of problem into independent parts
- In arch, separating components and connectors
- Complicated by:
  - Scattering:
    - Concern spread across many parts
      - e.g., logging
  - Tangling:
    - Concern interacts with many parts
      - e.g., performance

Architectural patterns

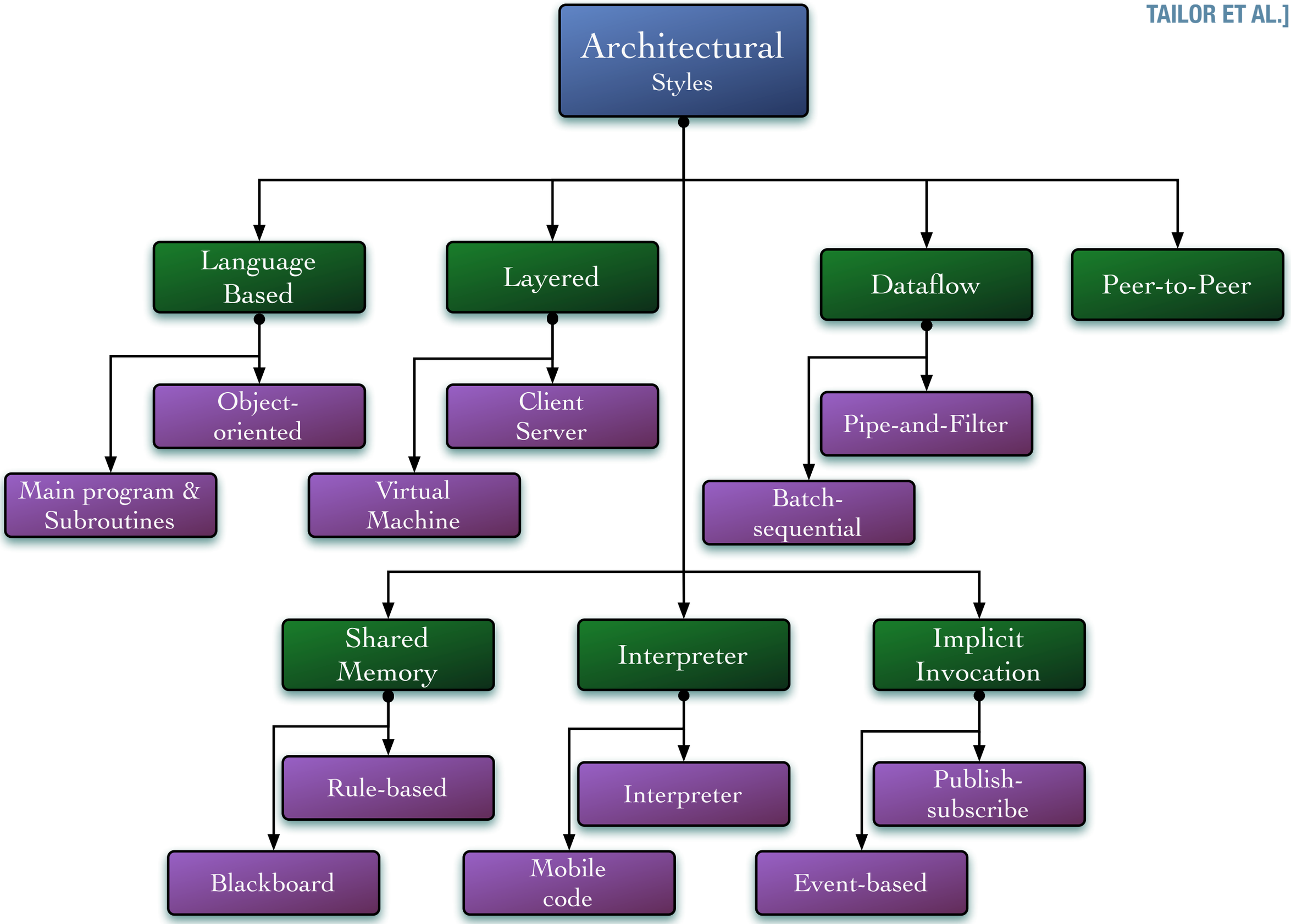
A set of architectural design decisions that are applicable to a recurring design problem, and parameterized to account for different software development contexts in which that problem appears.

e.g., Three-tier architectural pattern:

Architectural styles

- Some design choices are better than others
  - Experience can guide us towards beneficial sets of choices (patterns) that have positive properties
    - Such as?
- An architectural style is a named collection of architectural design decisions that:
  - Are applicable to a given context
  - Constrain design decisions
  - Elicit beneficial qualities in resulting systems

[TOPOLOGY FROM TAILOR ET AL.]



Lunar lander example

Style: Main program & subroutine

Style: Main program & subroutine

- Decomposition of functional elements.
- Components:
  - Main program and subroutines.
- Connections:
  - Function / procedure calls.
- Data elements:
  - Values passed in / out of subroutines.
- Topology:
  - Directed graph between subroutines and main program.

Style: Main program & subroutine

- Additional constraints:
  - None.
- Qualities:
  - Modularity, as long as interfaces are maintained.
- Typical uses:
  - Small programs.
- Cautions:
  - Poor scalability. Data structures are ill-defined.
- Relations to languages and environments:
  - BASIC, Pascal, or C.

Style: Object-oriented

Style: Object-oriented

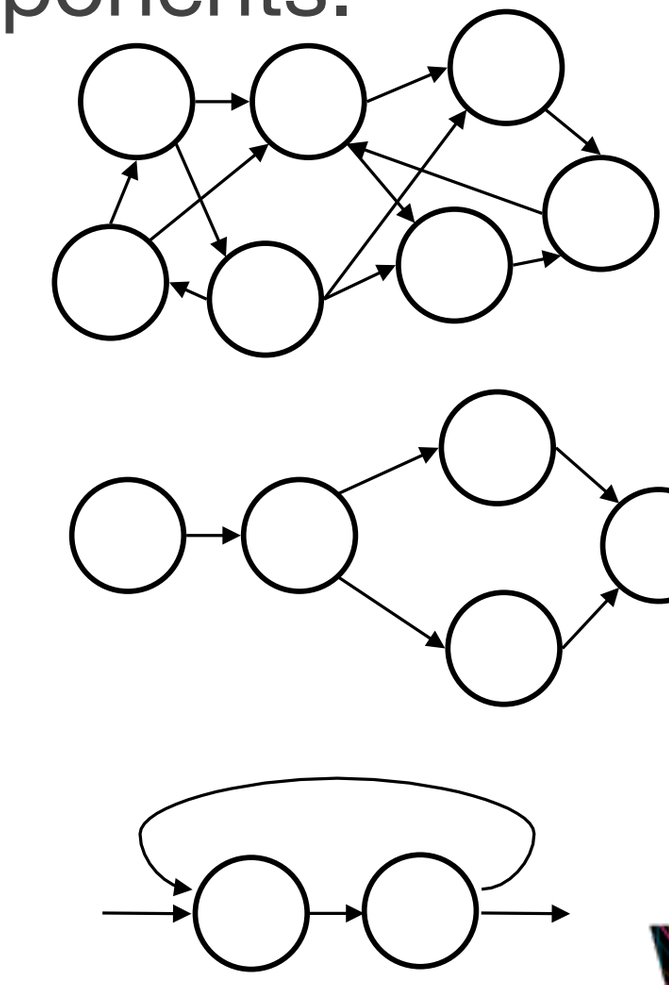
- Encapsulation of state and actions.
- Components:
  - Objects or ADTs.
- Connections:
  - Method calls.
- Data elements:
  - Method arguments.
- Topology:
  - Varies. Data shared through calls and inheritance.

Style: Object-oriented

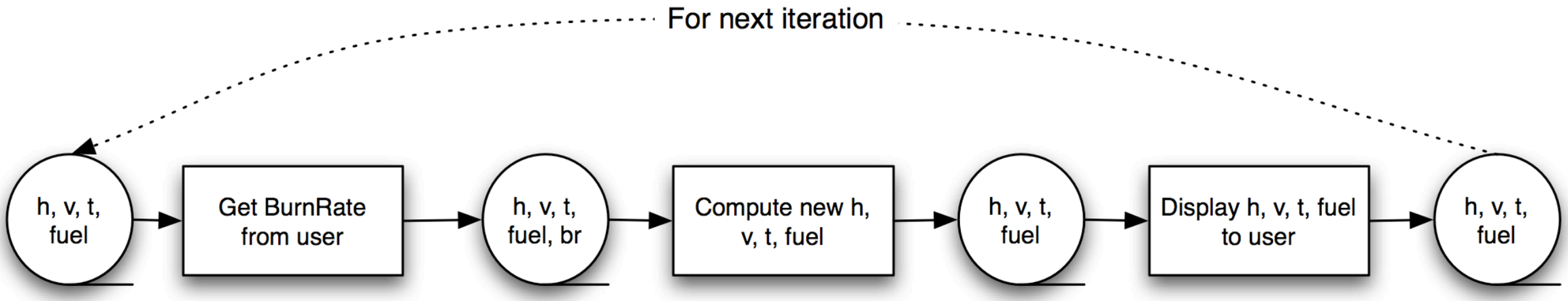
- Additional constraints:
  - Commonly used with shared memory (pointers). Object preserves identity of representation.
- Qualities:
  - Data integrity. Abstraction. Change implementations without affecting clients. Can break problems into interacting parts.
- Typical uses:
  - With complex, dynamic data. Correlation to real-world entities.
- Cautions:
  - Distributed applications hard. Often inefficient for sci. computing. Potential for high coupling via constructors. Understanding can be difficult.
- Relations to languages and environments:
  - C++, Java.

Dataflow

- A data flow system is one in which:
- The availability of data controls computation.
- The structure of the design is determined by the orderly motion of data between components.
- The pattern of data flow is explicit.
- Variations:
- Push vs. pull.
- Degree of concurrency.
- Topology.



Style: Batch-sequential



[TAILOR ET AL.]

Style: Batch-sequential

- Separate programs executed in order passed, each step proceeding after the the previous finishes.
- Components:
  - Independent programs.
- Connections:
  - Sneaker-net.
- Data elements:
  - Explicit output of complete program from preceding step.
- Topology:
  - Linear.

Style: Batch-sequential

- Additional constraints:
  - One program runs at a time (to completion).
- Qualities:
  - Interruptible execution.
- Typical uses:
  - Transaction processing in financial systems.
- Cautions:
  - Programs cannot easily feed back in to one another.

Style: Pipe-and-filter

Style: Pipe-and-filter

- Streams of data are passed concurrently from one program to another.
- Components:
  - Independent programs (called filters).
- Connections:
  - Explicitly routed by OS.
- Data elements:
  - Linear data streams, often text.
- Topology:
  - Typically pipeline.

Style: Pipe-and-filter

- Qualities:
  - Filters are independent and can be composed in novel sequences.
- Typical uses:
  - Very common in OS utilities.
- Cautions:
  - Not optimal for interactive programs or for complex data structures.

Style: Blackboard

Style: Blackboard

- Independent programs communicate exclusively through shared global data repository.
- Components:
  - Independent programs (knowledge sources), blackboard.
- Connections:
  - Varies: memory reference, procedure call, DB query.
- Data elements:
  - Data stored on blackboard.
- Topology:
  - Star; knowledge sources surround blackboard.

Style: Blackboard

- Variants:
  - Pull: clients check for blackboard updates.
  - Push: blackboard notifies clients of updates.
- Qualities:
  - Efficient sharing of large amounts of data. Strategies to complex problems do not need to be pre-planned.
- Typical uses:
  - Heuristic problem solving.
- Cautions:
  - Not optimal if regulation of data is needed or the data frequently changes and must be updated on all clients.