CMPT 373
Software Development Methods

A Tour of
Software Architecture

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Managing complexity through design

- Recall: Fundamental problem in software development is *managing complexity*

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- One key tool in managing and guiding complexity is *software architecture*
  - The overall *structure* of a system including its components, how they *communicate* (interfaces & protocols), how they *control* behavior, and *nonfunctional* requirements
- The issues cross boundaries of scale and context
  - design patterns ↔ enterprise system designs
  - monolithic ↔ microservice

Goals of architecture

- Software architecture should help
  - *Identify* and analyze key design constraints
  - *Analyze* the trade-offs of design options

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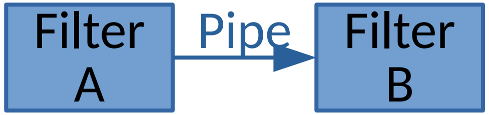
- Common patterns and styles arise from goals and requirements
  - (Several of which you are already supposed to know….)

Classical architectural styles [Garlan & Shaw, 1994]

- Pipe and filter/ Pipeline
  - *Filters* operate on data format
  - *Pipes* connect the filters together



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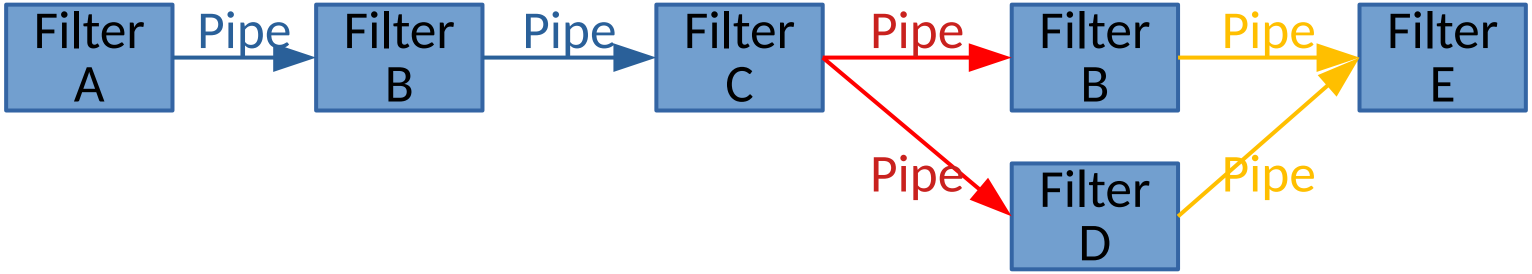

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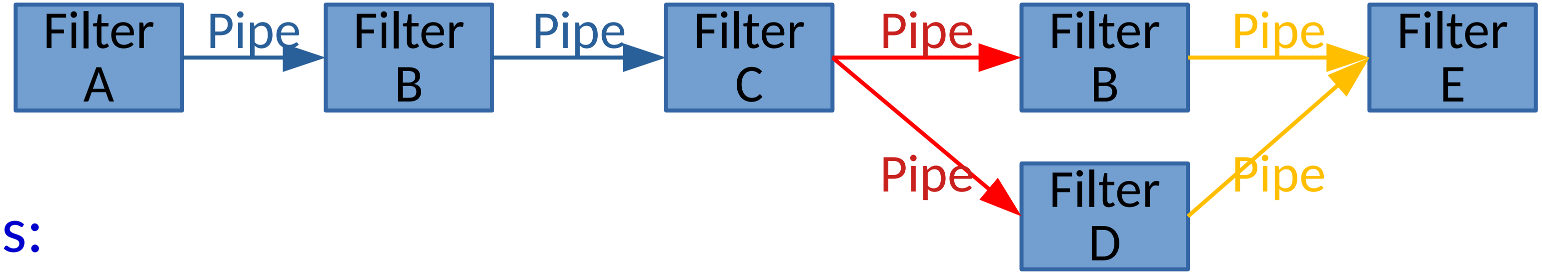

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  - Understanding flow & maintenance is easy
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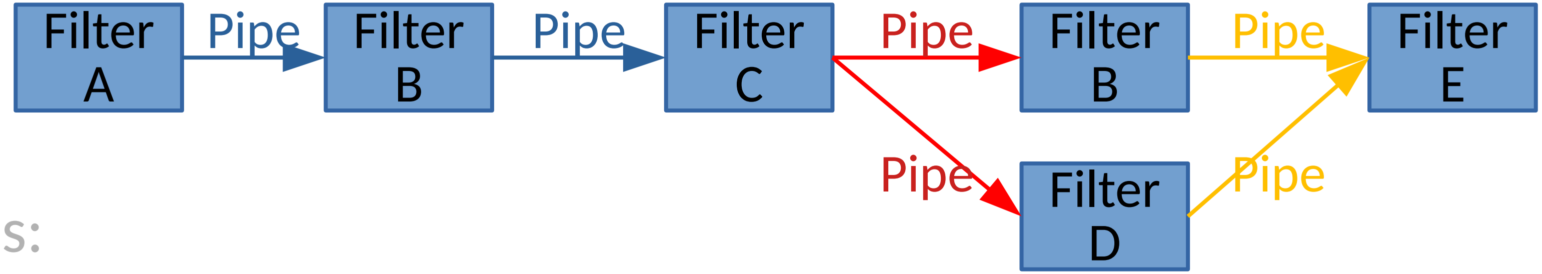

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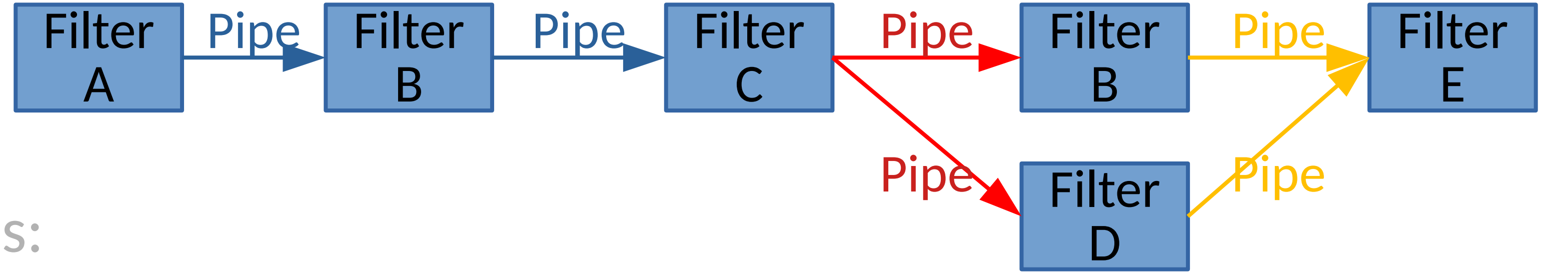

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- Example: Unix Pipes

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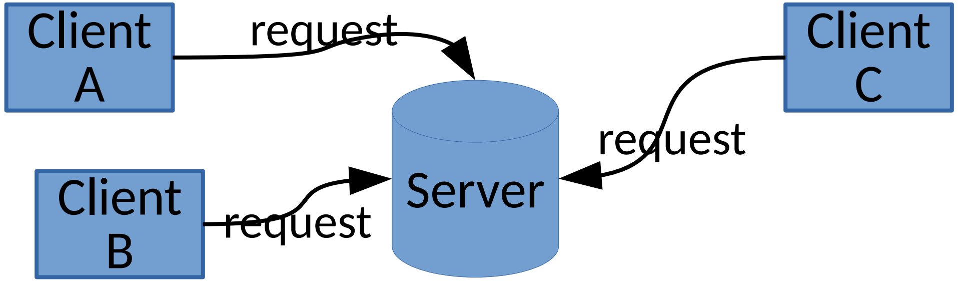

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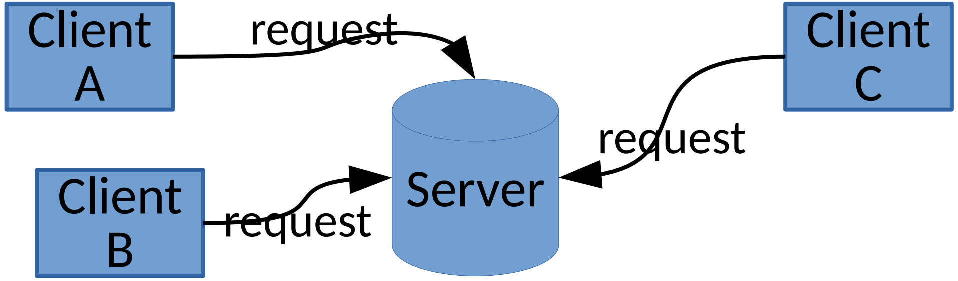

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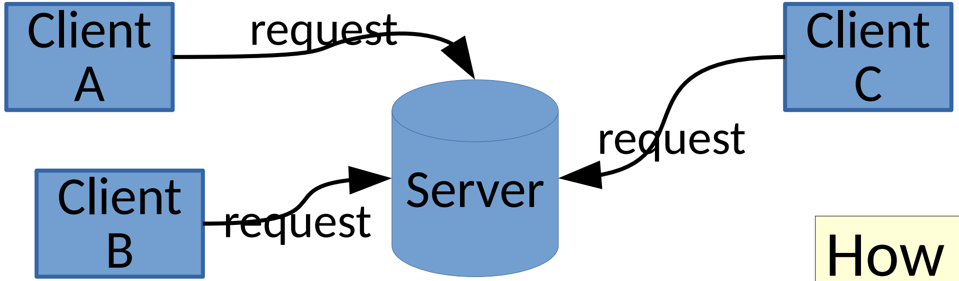

How does this relate to our discussion on complexity?

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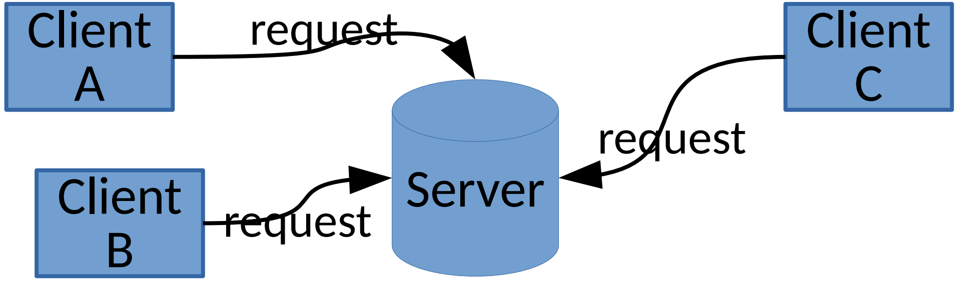

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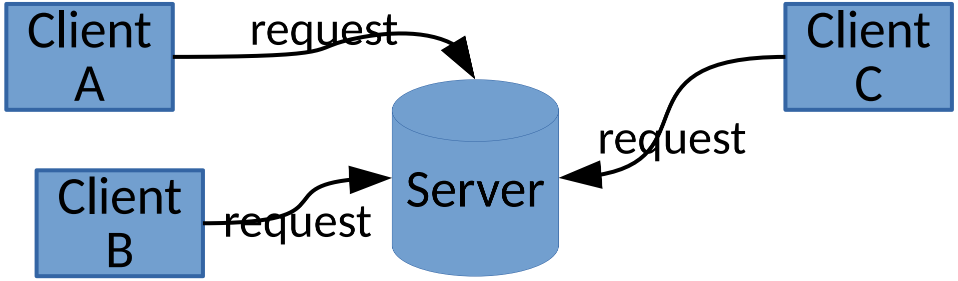
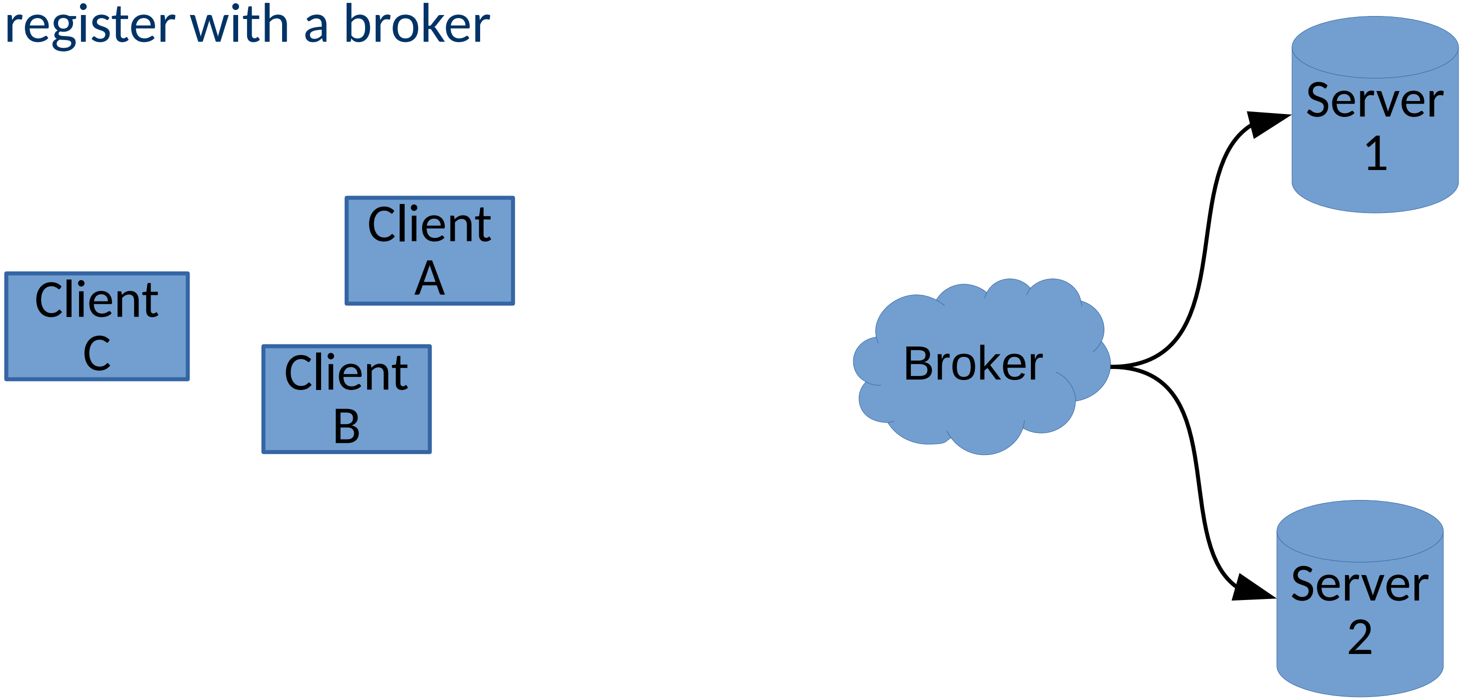


- Pros:
  - Clients are independent & decoupled
- Cons:
  - Clients are coupled to the server. (How easy is the server to replace?)

Classical architectural styles

- Broker
  - Servers register with a broker



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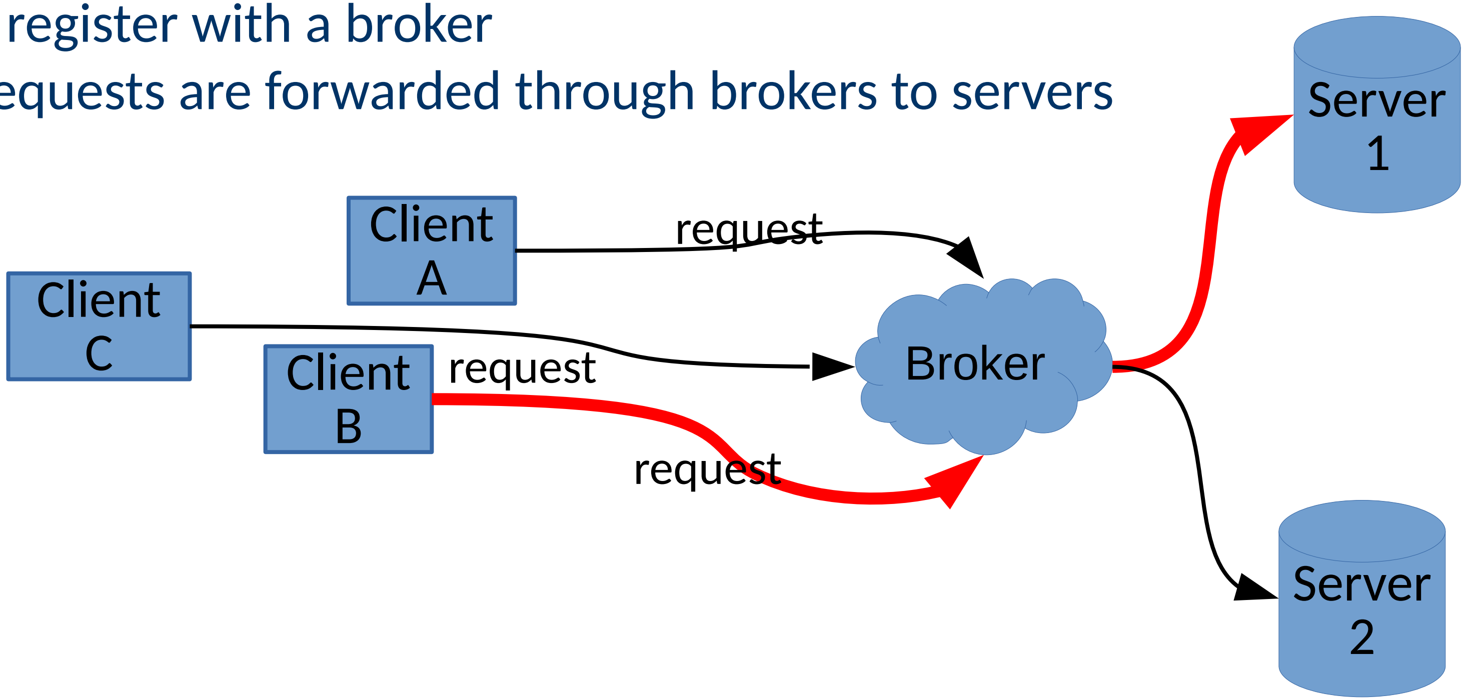

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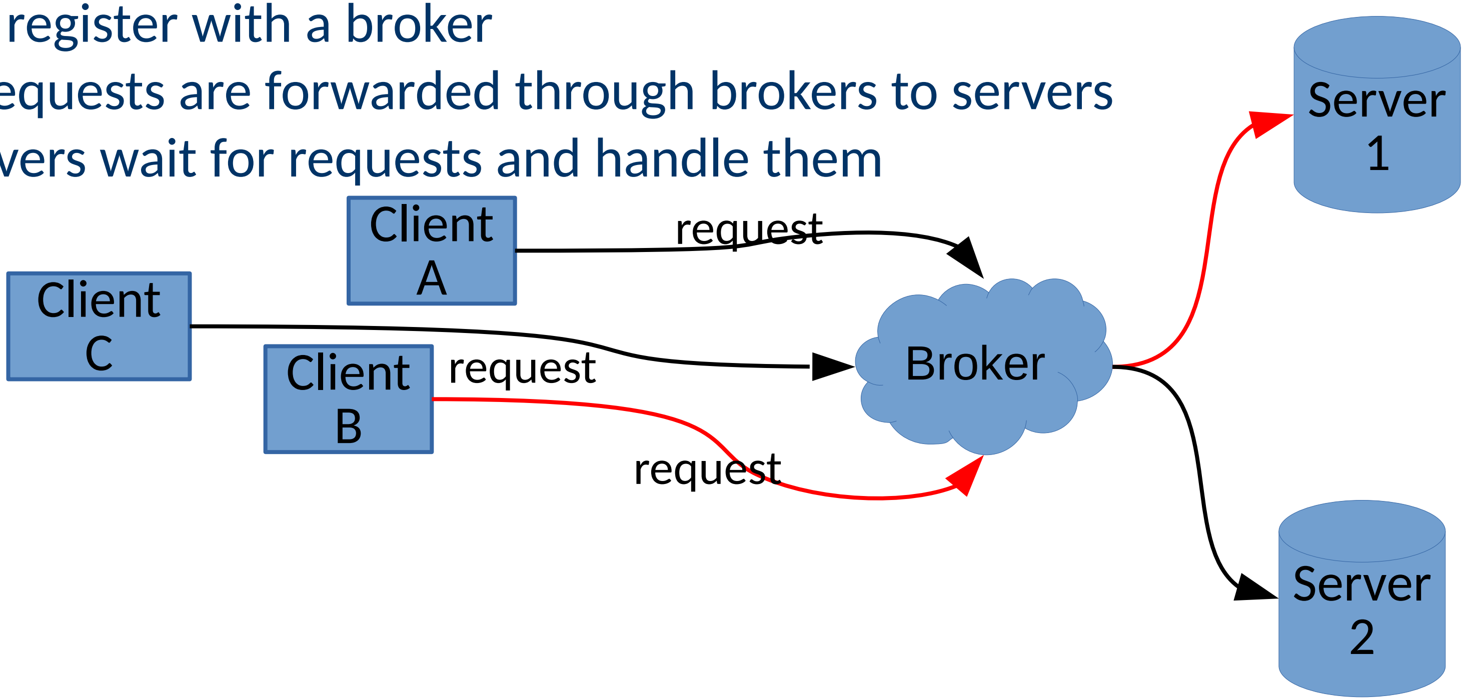

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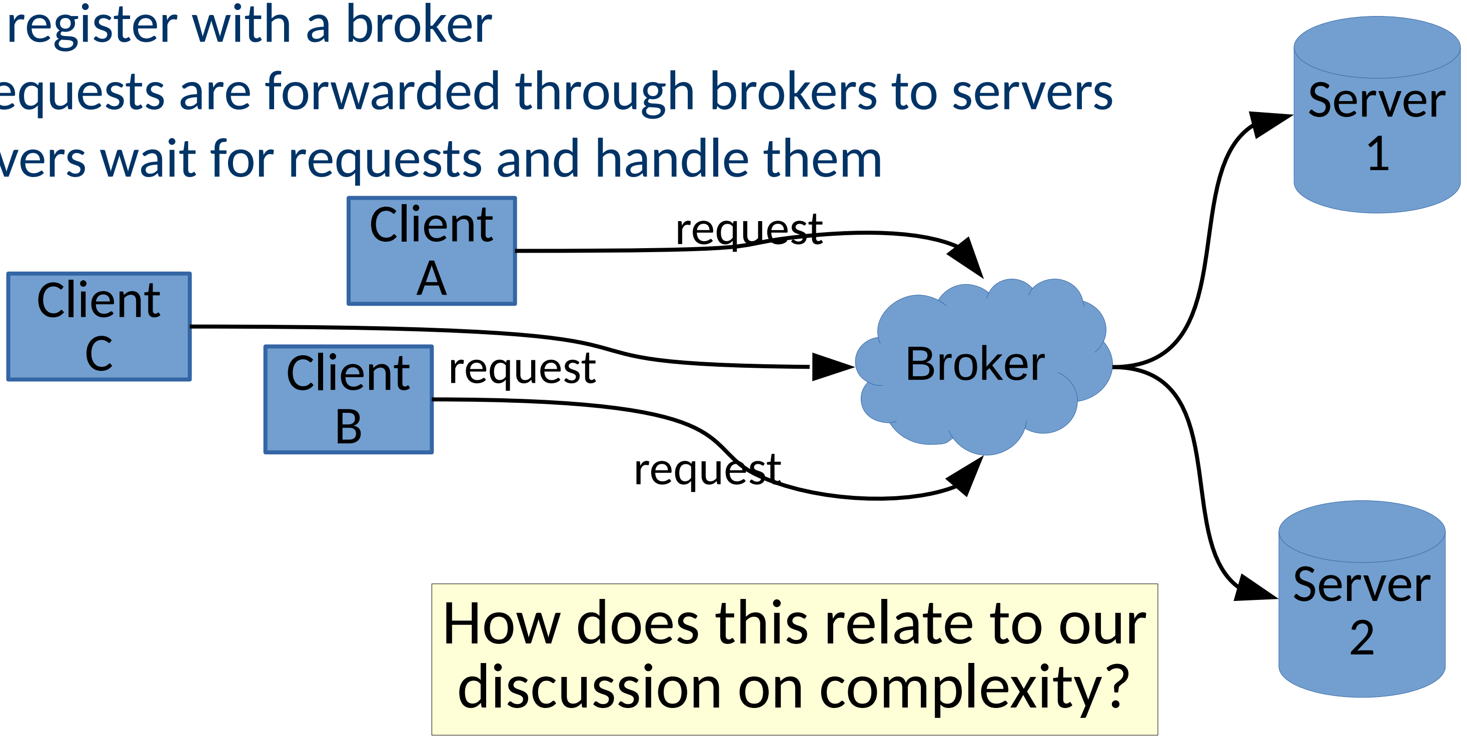

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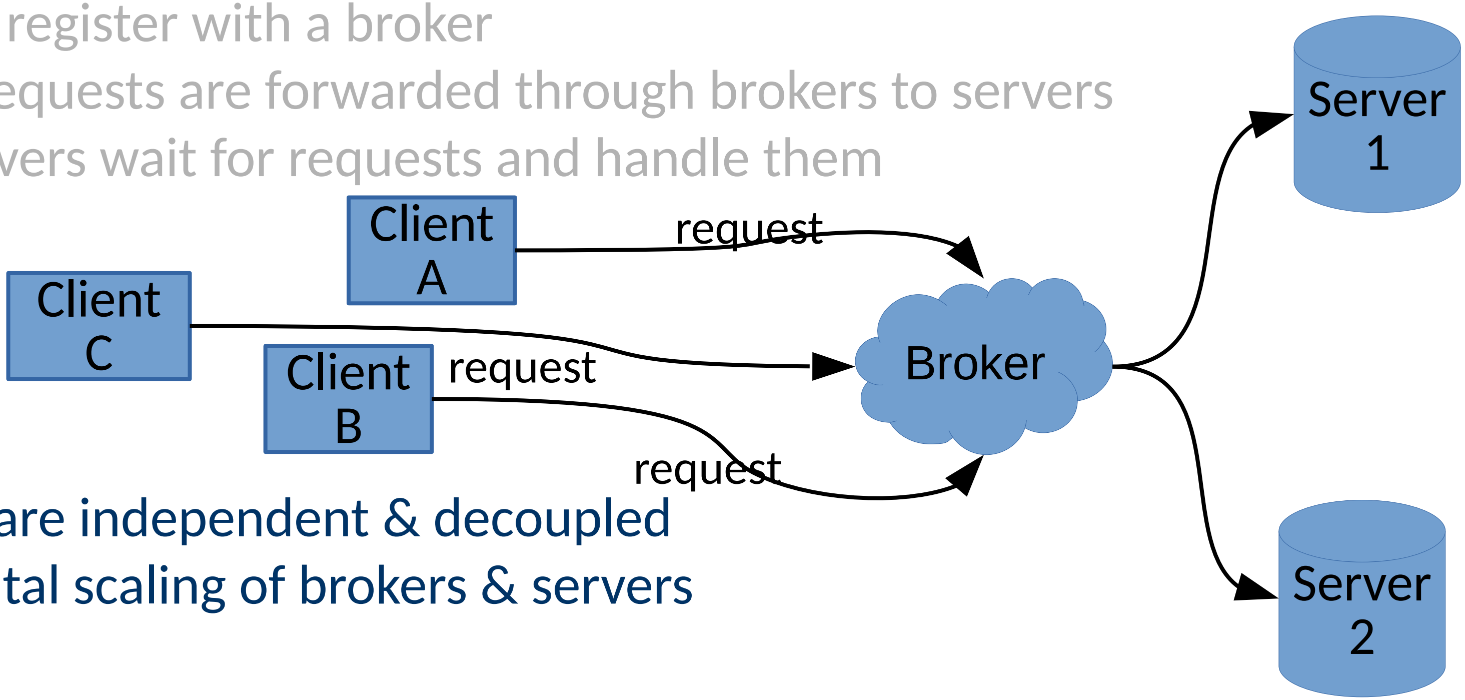

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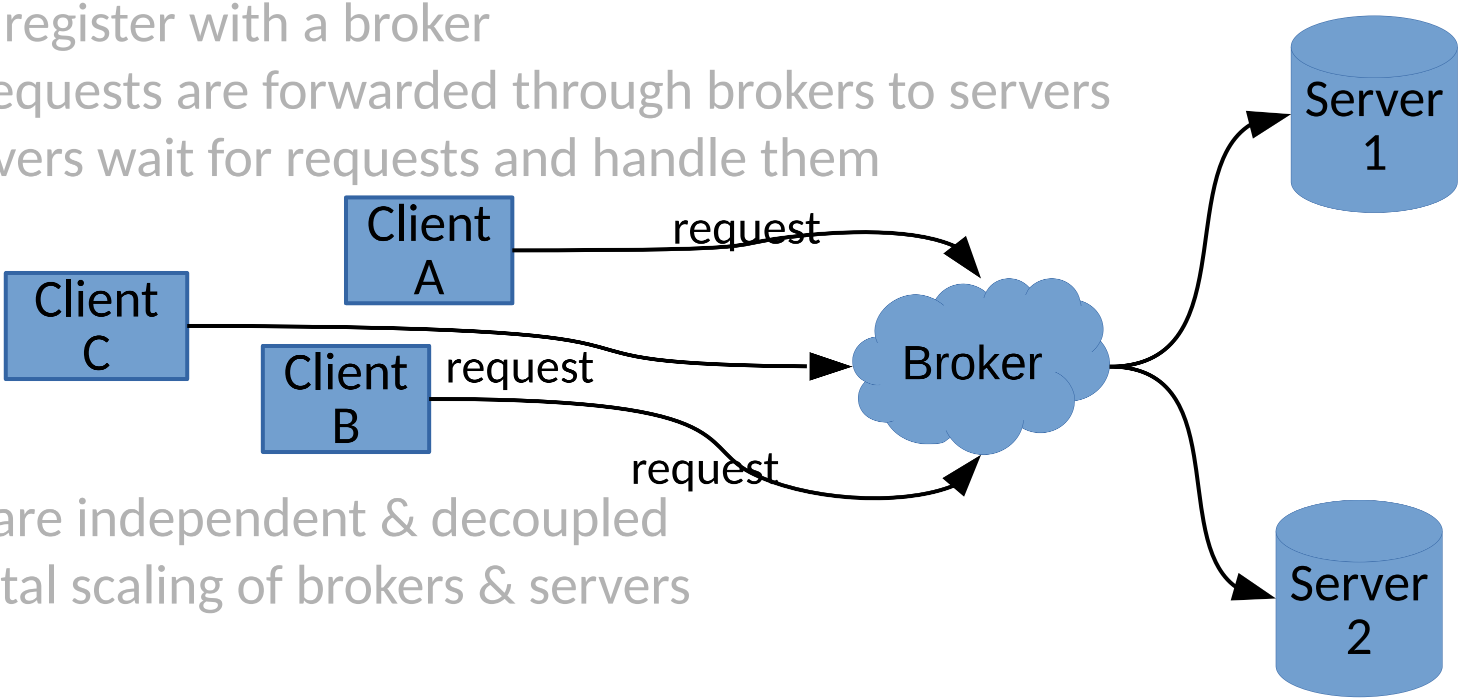
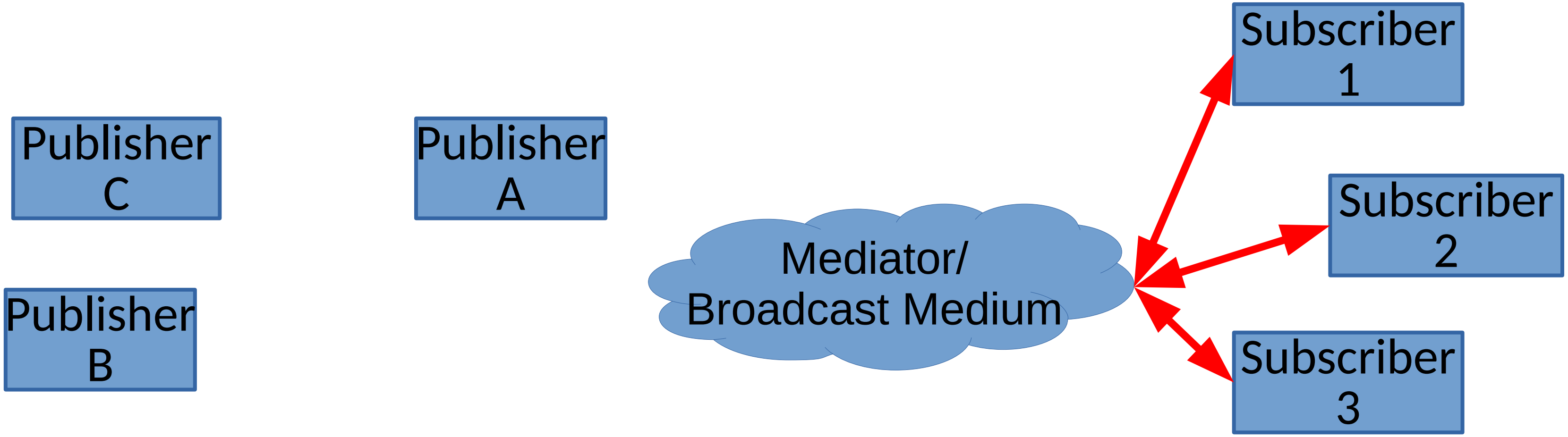


- Pros:
  - Clients are independent & decoupled
  - Horizontal scaling of brokers & servers
- Cons:
  - Brokers themselves become a single point of failure
  - Starts to involve many components (complexity)

Classical architectural styles [Garlan & Shaw, 1994]

- Publish-Subscribe (event based / observer / …)
  - Event subscribers register with a mediator or by broadcast



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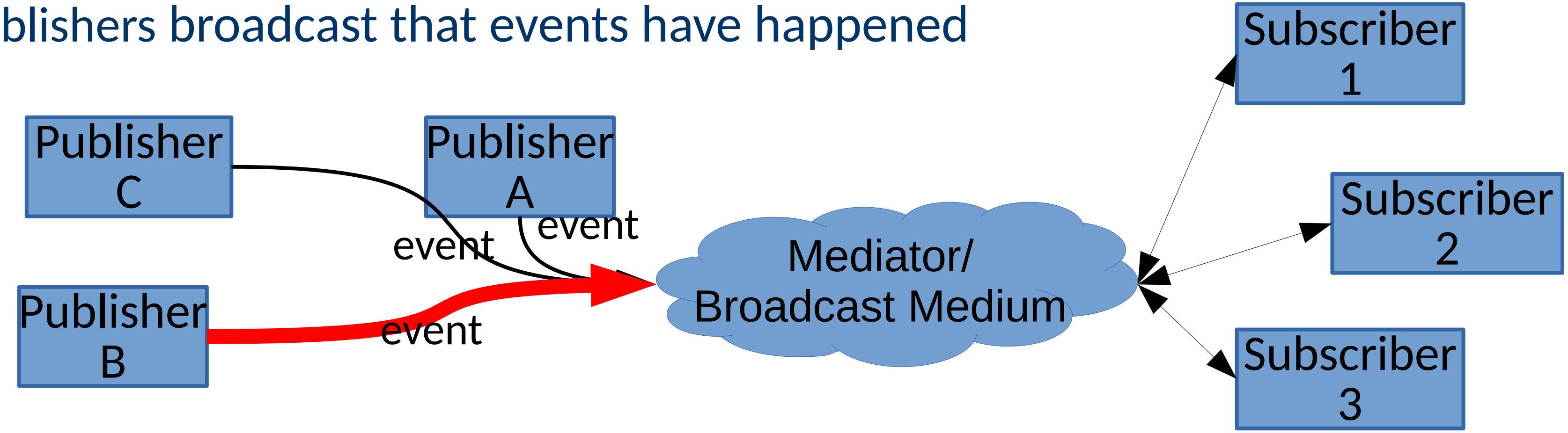

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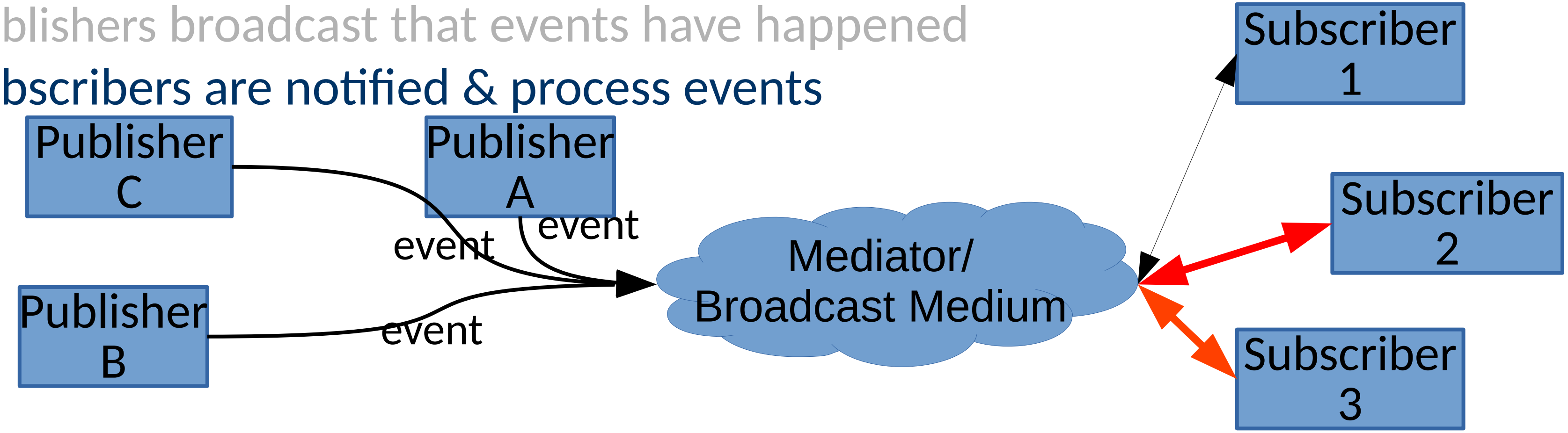

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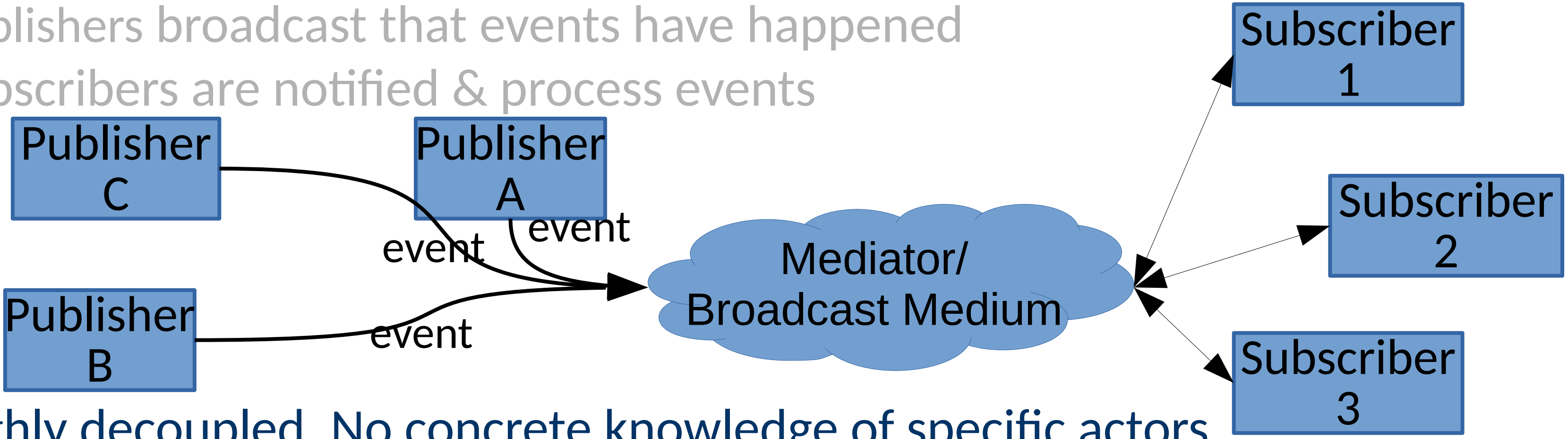

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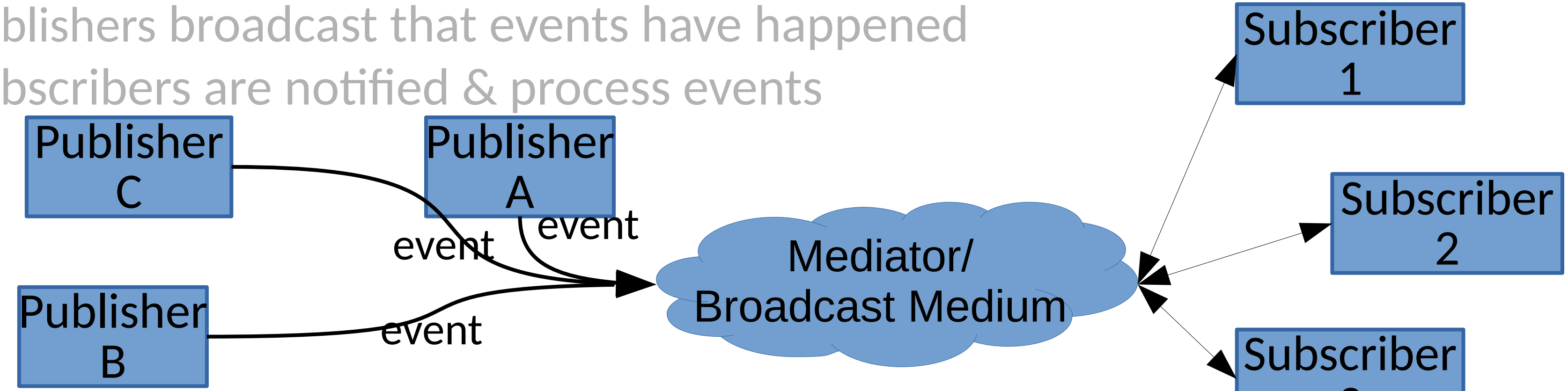

- Pros:
  - Highly decoupled. No concrete knowledge of specific actors.
  - Very easy reuse.
- Cons:
  - No guarantees on ordering
  - If actors are not actually independent, it becomes challenging to understand

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  - Cohesive abstractions separated into layers

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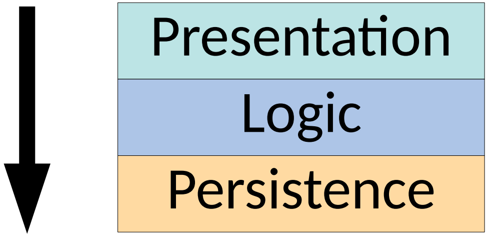

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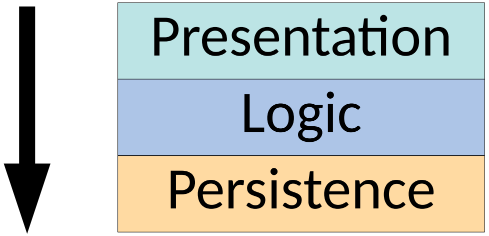

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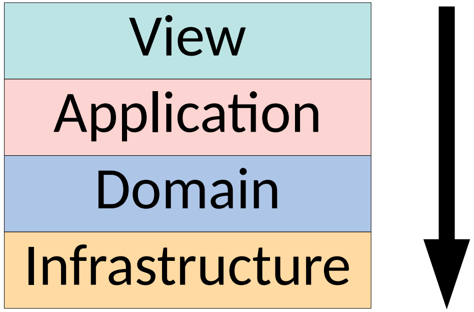
Logic

Persistence



View

Application

Domain

Infrastructure

[Cunningham]

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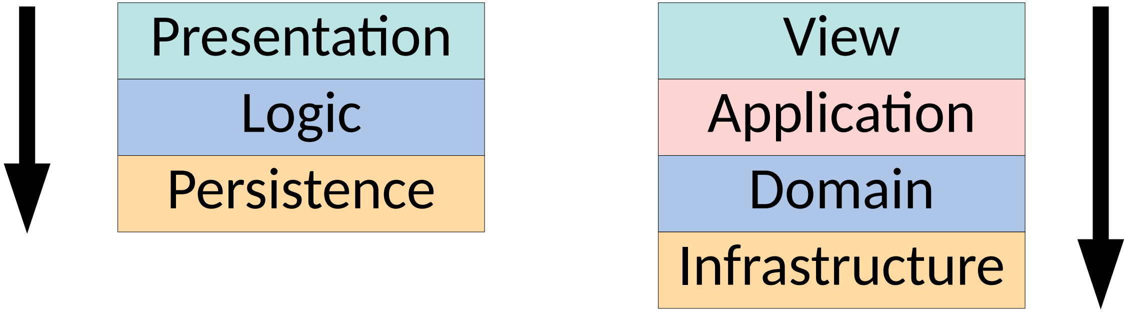

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- Pros:
  - Clear interfaces can allow layers to be replaced
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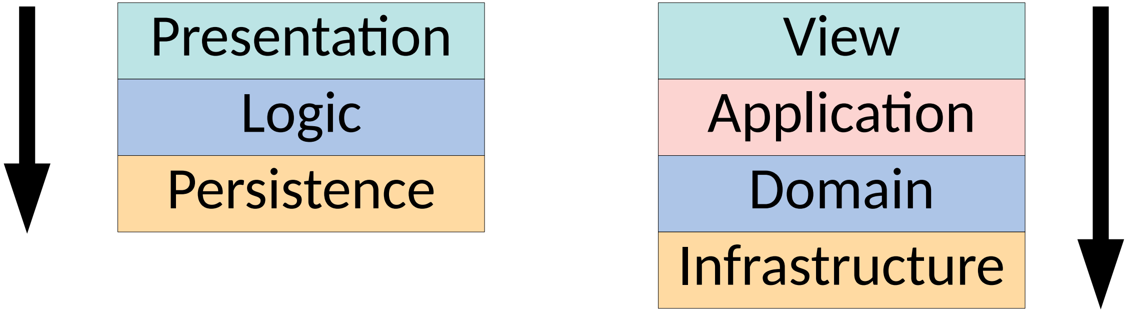

Presentation
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[Cunningham]

- Pros:
  - Clear interfaces can allow layers to be replaced
  - Each layer can be focused
- Cons:
  - How can we identify clear layer boundaries?
  - Higher layers may be coupled to lower layers

Classical architectural styles [Garlan & Shaw, 1994]

- Others
  - MVC, MVVM, …
  - Blackboard
  - Repository
  - Table driven
  - …

More recent styles

- Layering and decoupling are pushed further

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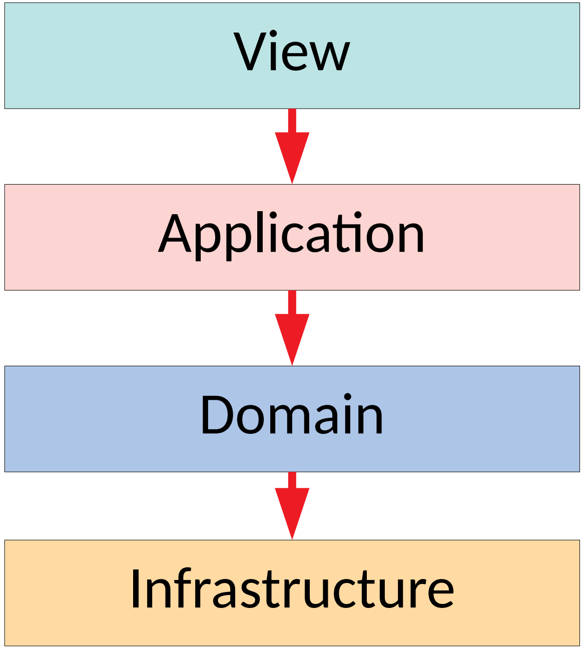

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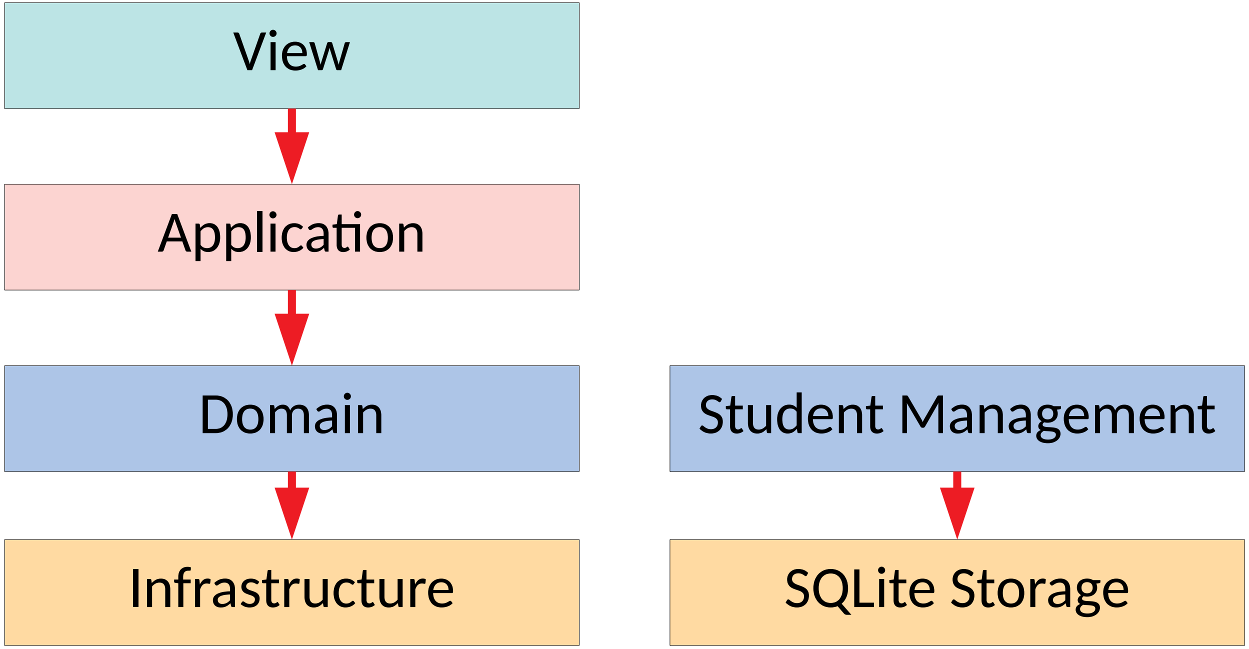

What if you want some other storage?

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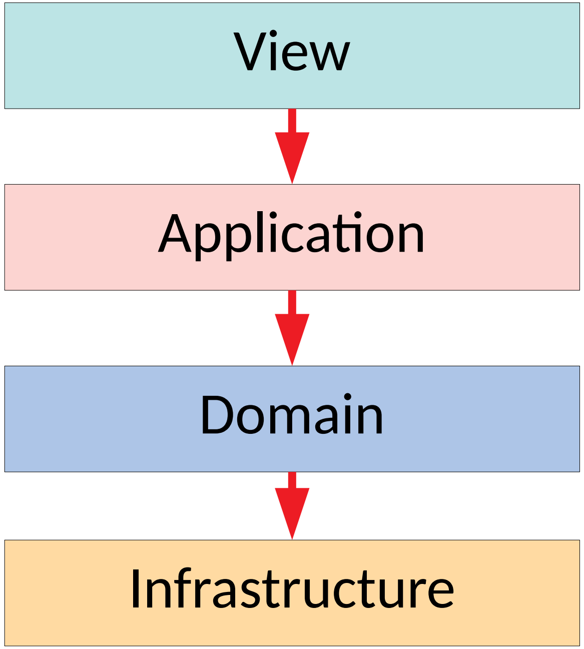
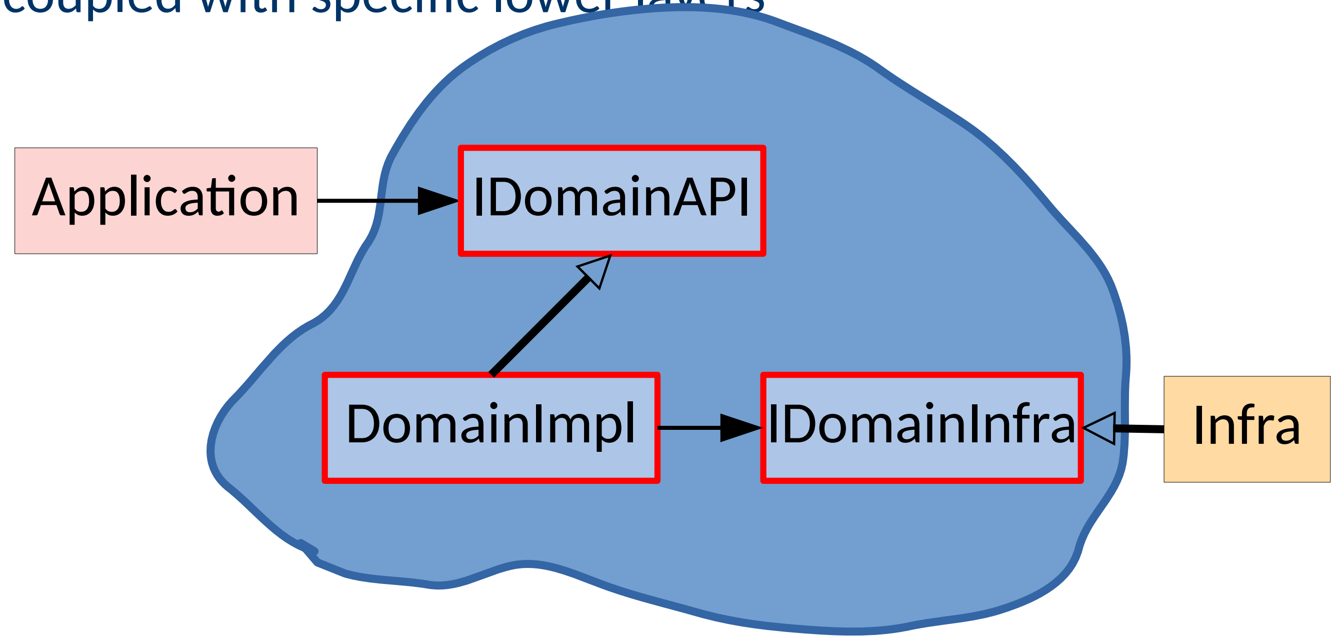


View

Application

Domain

Infrastructure



Application

IDomainAPI

DomainImpl

IDomainInfra

Infra

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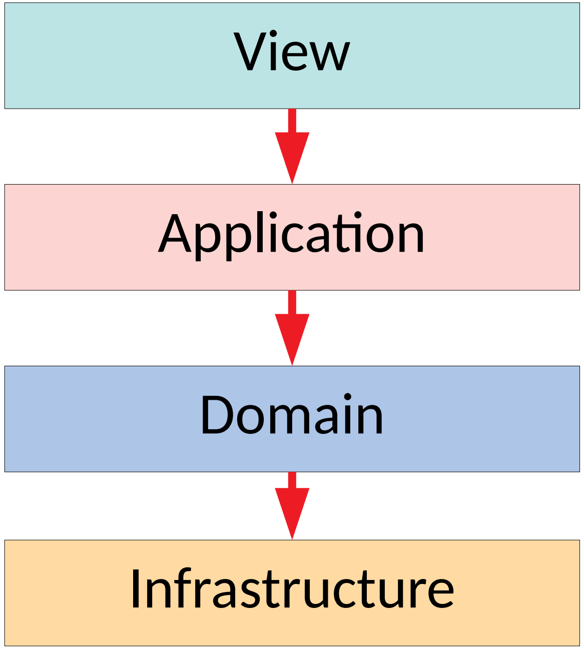
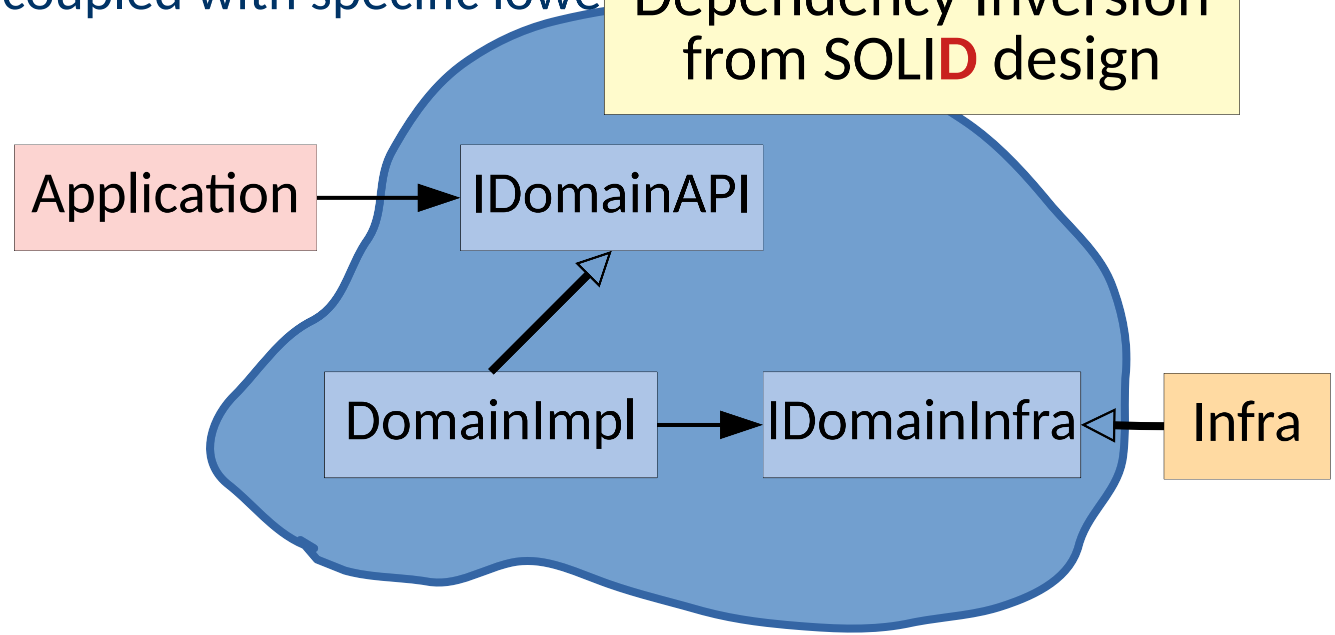


Dependency Inversion from SOLID design



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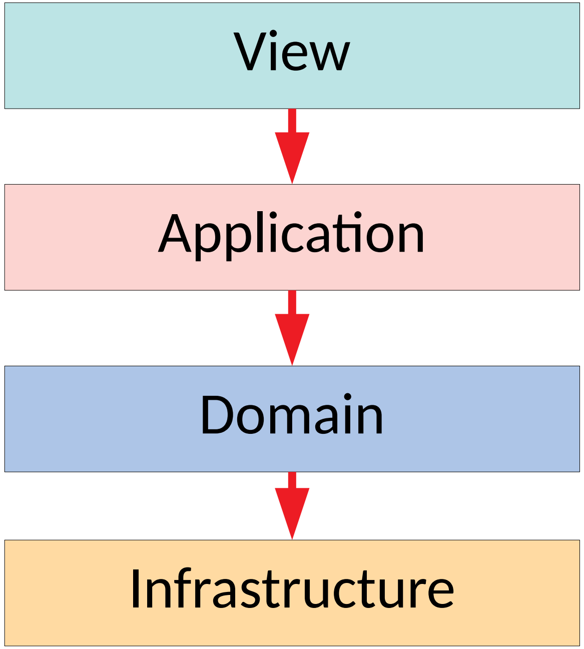

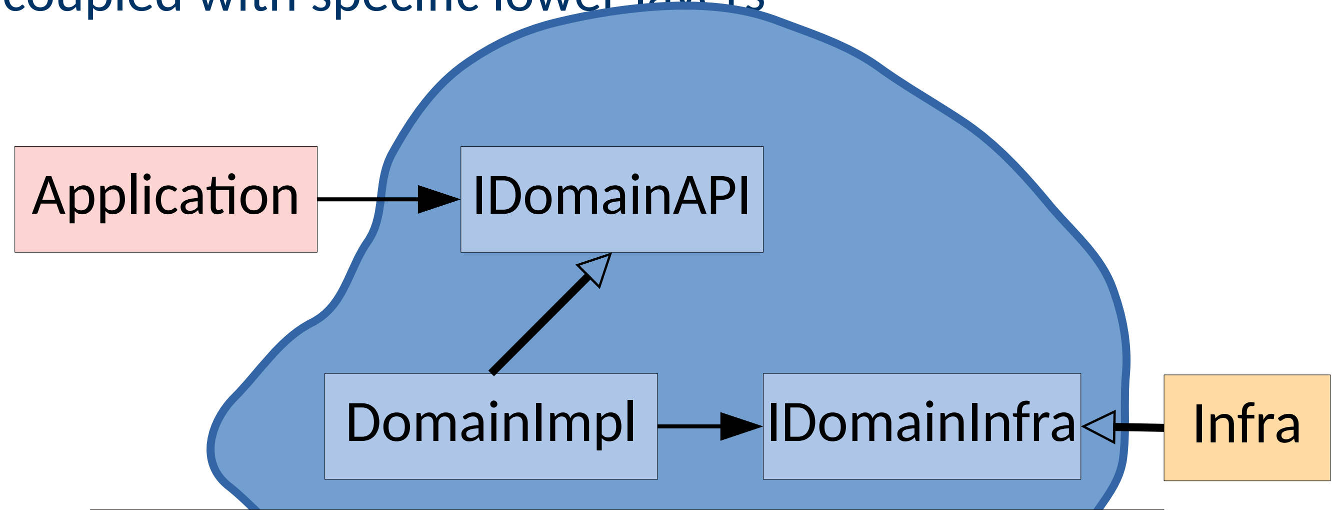

What happens when we apply
this to all interactions with the domain?

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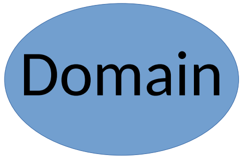

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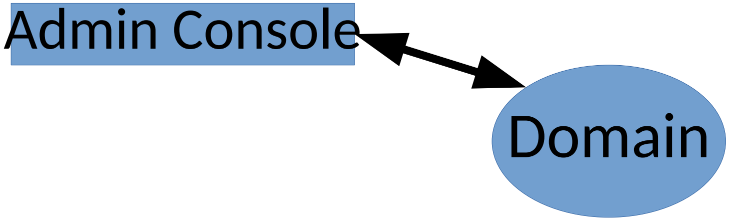

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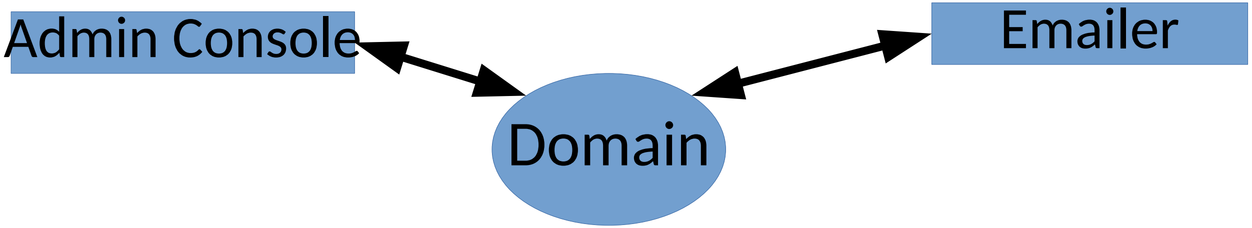

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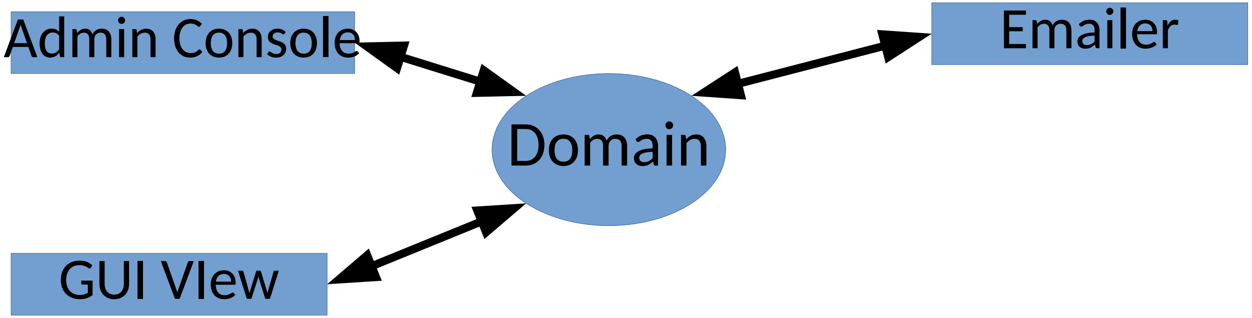

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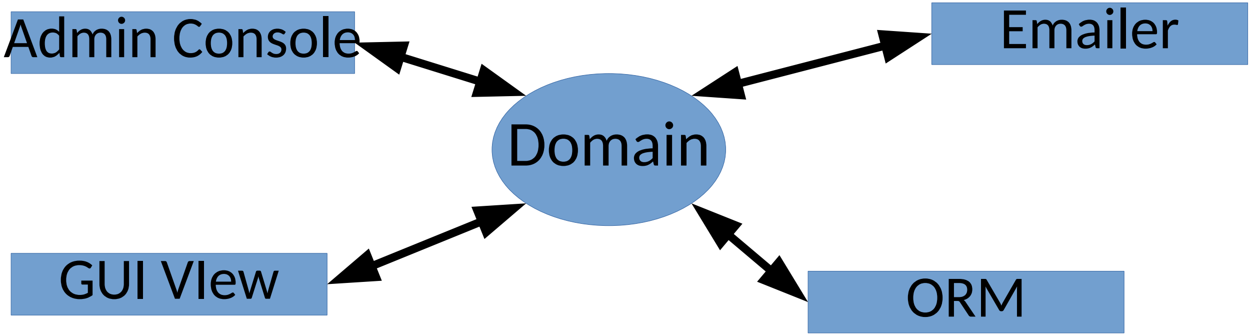

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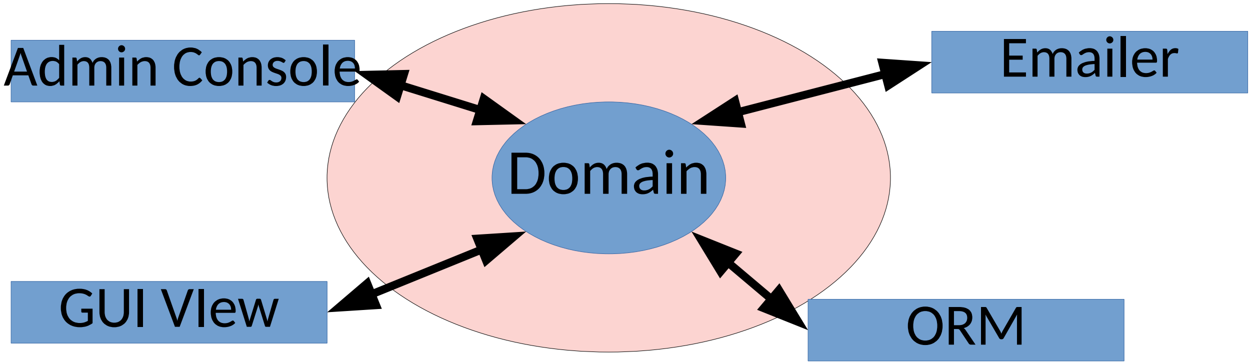

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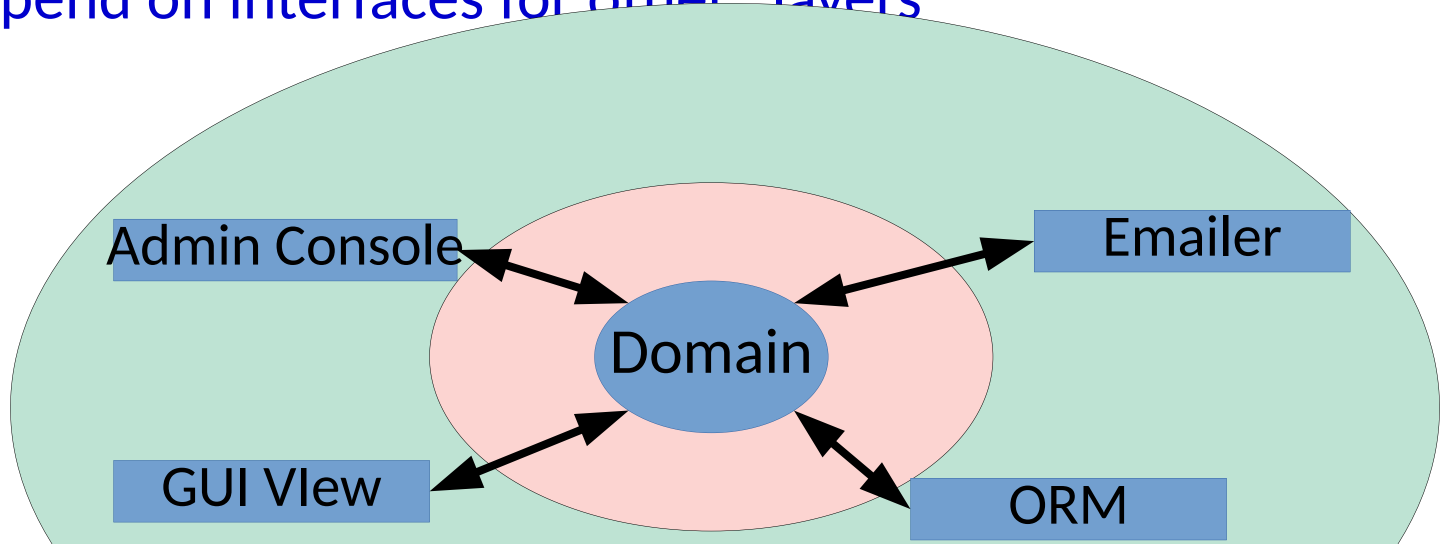

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- Focus on your "layer" or component at the core, and depend on interfaces for other "layers"
- This is known as:
  - Hexagonal architecture
  - Ports & adaptors
  - Onion architecture
  - Clean architecture

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  - Service oriented architecture

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  - Microservices
  - …

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- 2 Common hurdles prevent visualizing & discussing design well

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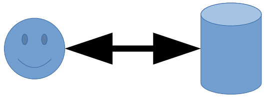
  - Be careful. UML is only a tool for communication. It is not design.
- 2 Common hurdles prevent visualizing & discussing design well
  - Hierarchy / Abstraction



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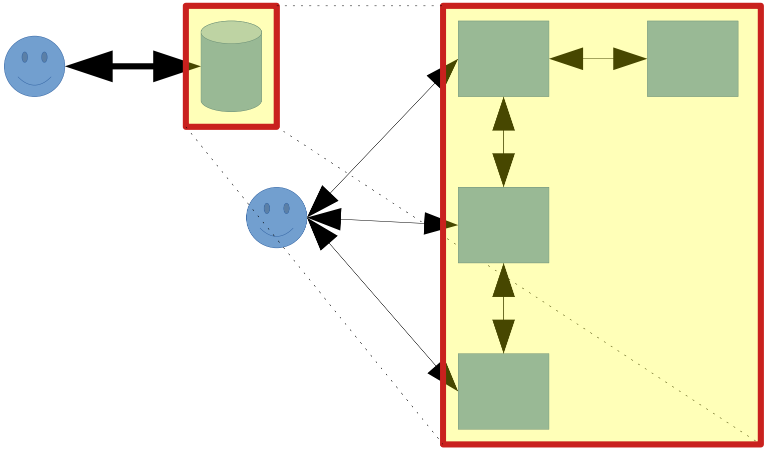

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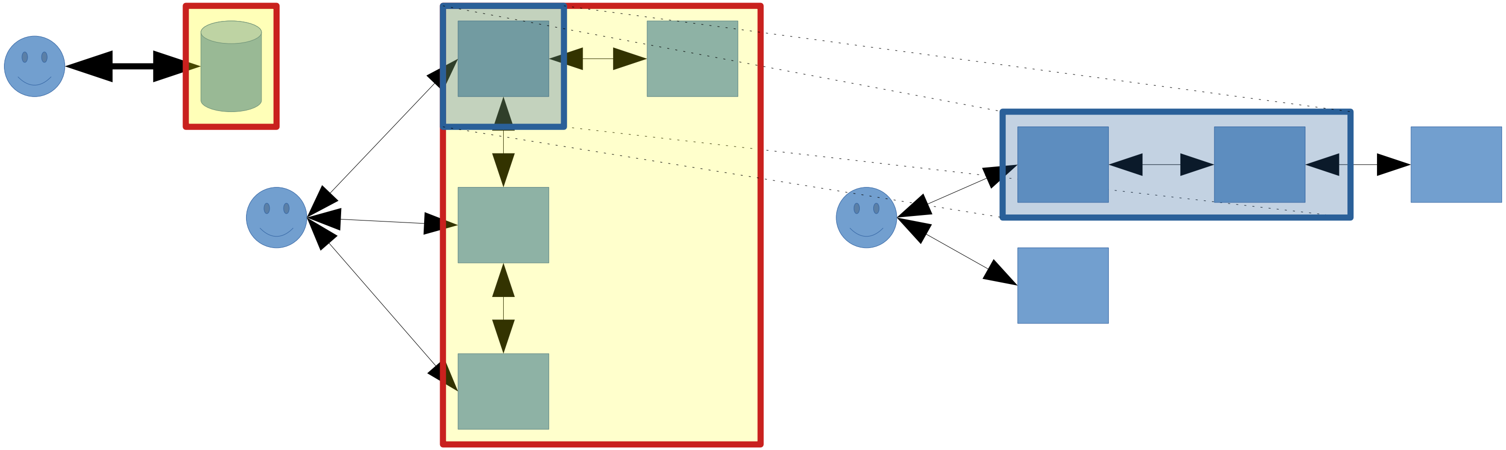

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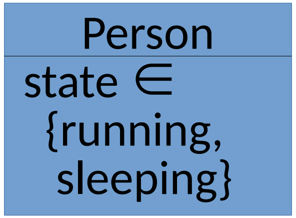

Person

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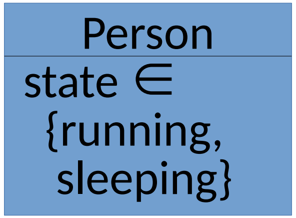

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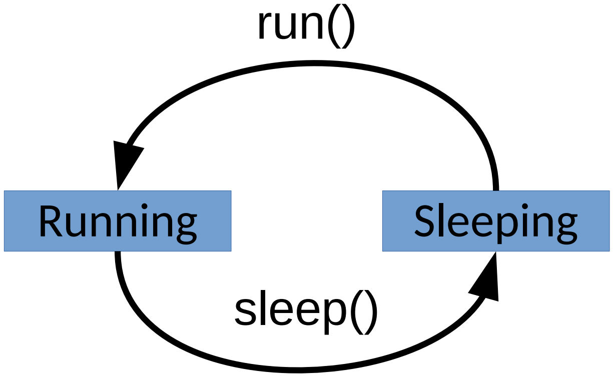

run()

Running

Sleeping

sleep()

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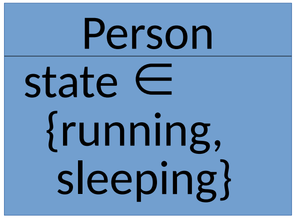

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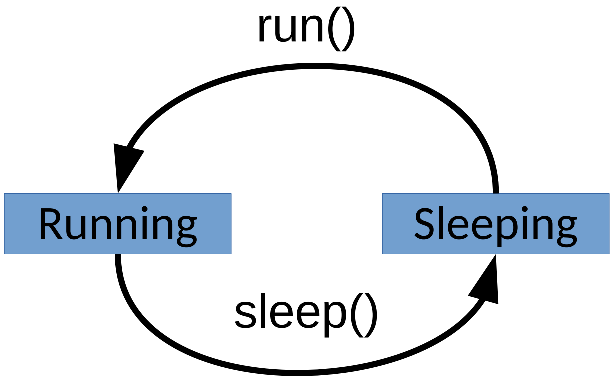

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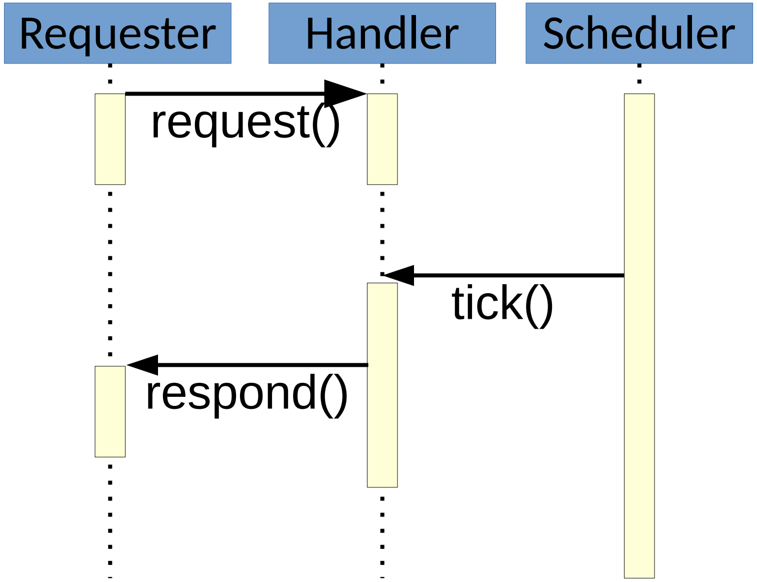

Requester

Handler

Scheduler

request()

tick()

respond()

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- Consider a system from multiple hierarchies to avoid missing the big picture
- Consider both static & dynamic contexts

Tips

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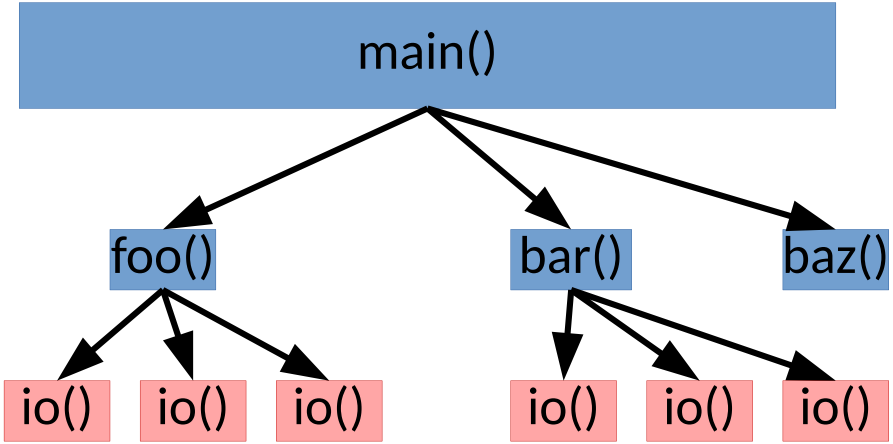

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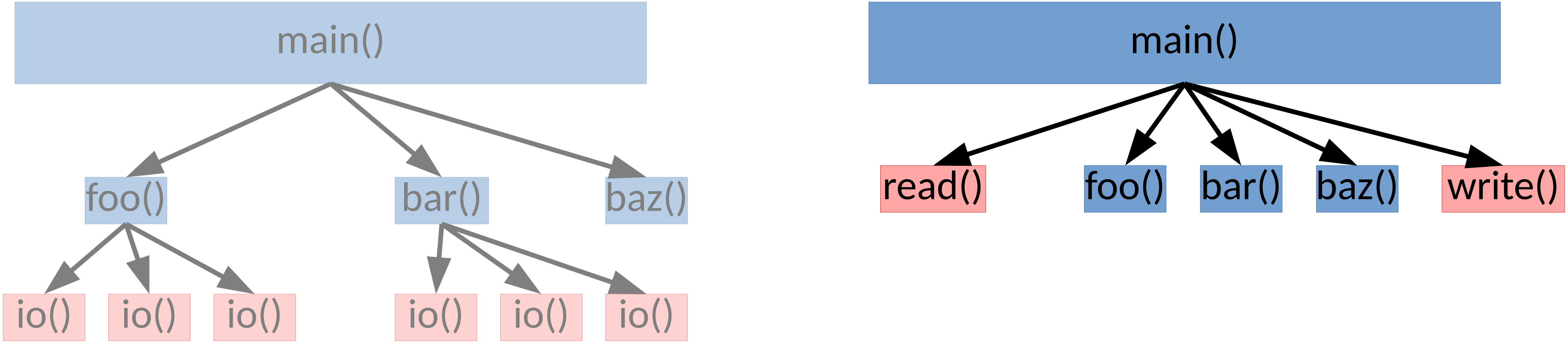

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- Prefer batch processing unless incrementality is required
  - Operating at Google scale can require incrementality
  - Batch processing is clearer & groups related code if you can use it

Tips

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- Prefer batch processing unless incrementality is required
- Prefer to keep your in-flight data immutable
  - It is easier to see where a bad object was created than when it was corrupted

Tips

- Prefer to reduce the number of boundary crossings and the # of places they happen
- Prefer batch processing unless incrementality is required
- Prefer to keep your in-flight data immutable
- Start by following a user story through the system. Follow the data.
  - Where is data created?
  - Where is data transformed or consumed?
  - Where is new data made observable?

  All of these indicate components.

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How do we decide the boundaries of a component?

Summary

- There are several architectural idioms that can be useful in creating a flexible program

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- Cleanly separating out layers & interfaces is crucial in modern designs

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- There are several architectural idioms that can be useful in creating a flexible program
- Cleanly separating out layers & interfaces is crucial in modern designs
- When first designing, follow the data of a user story