

# Informatics 43

LECTURE 5-1

EMILY NAVARRO

# Today's lecture

- Software architecture - recap
- Architectural styles
- Evolution

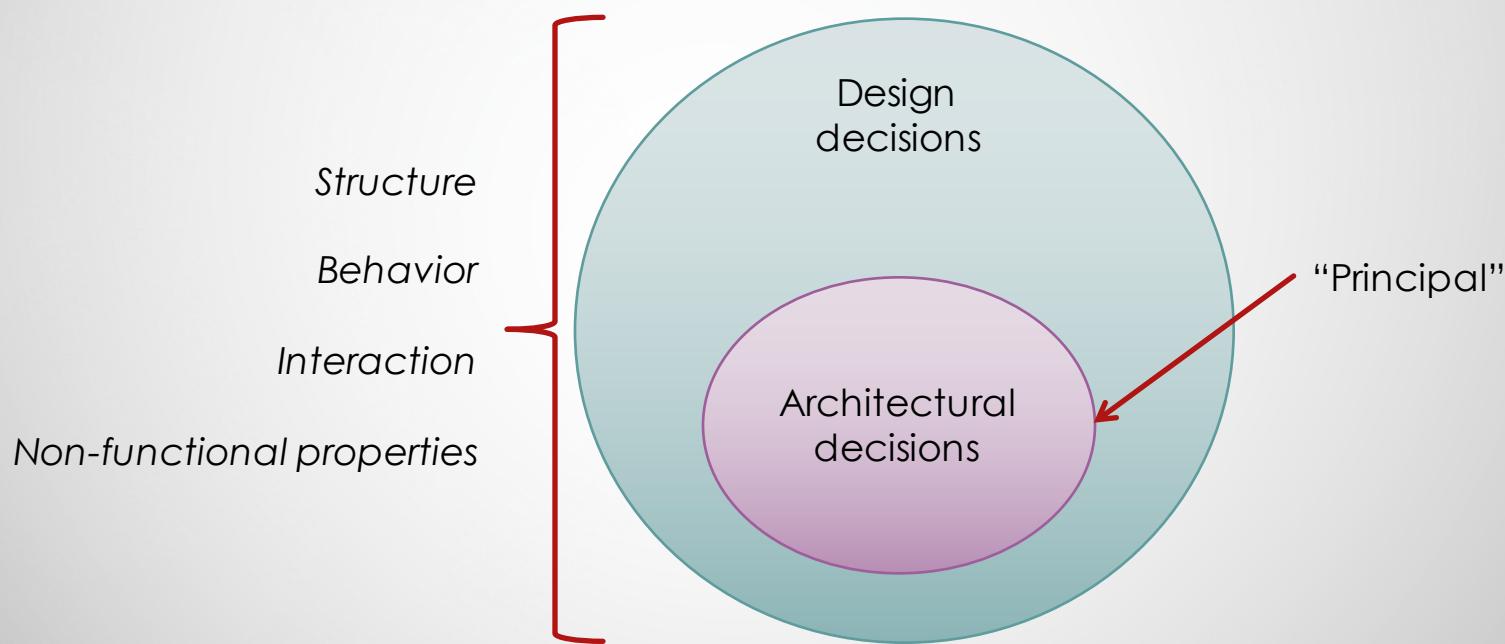
*Some slides adopted and adapted from "Software Architecture: Foundations, Theory, & Practice" by Taylor, Medvidovic, and Dashofy*

# Today's lecture

- Software architecture - recap
- Architectural styles
- Evolution

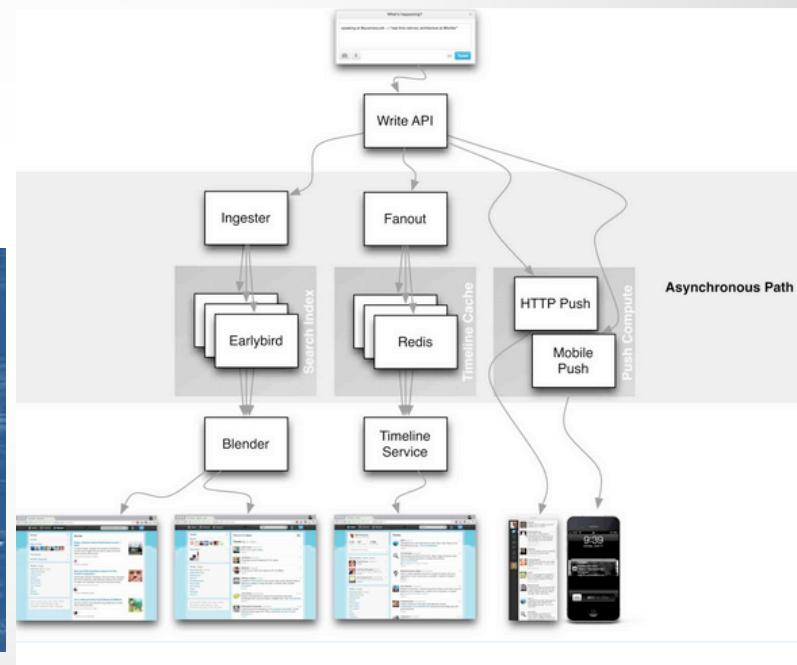
# Defining software architecture

A software system's architecture is the set of *principal design decisions* about the system



# Defining software architecture

Software architecture is the blueprint for a software system's construction and evolution



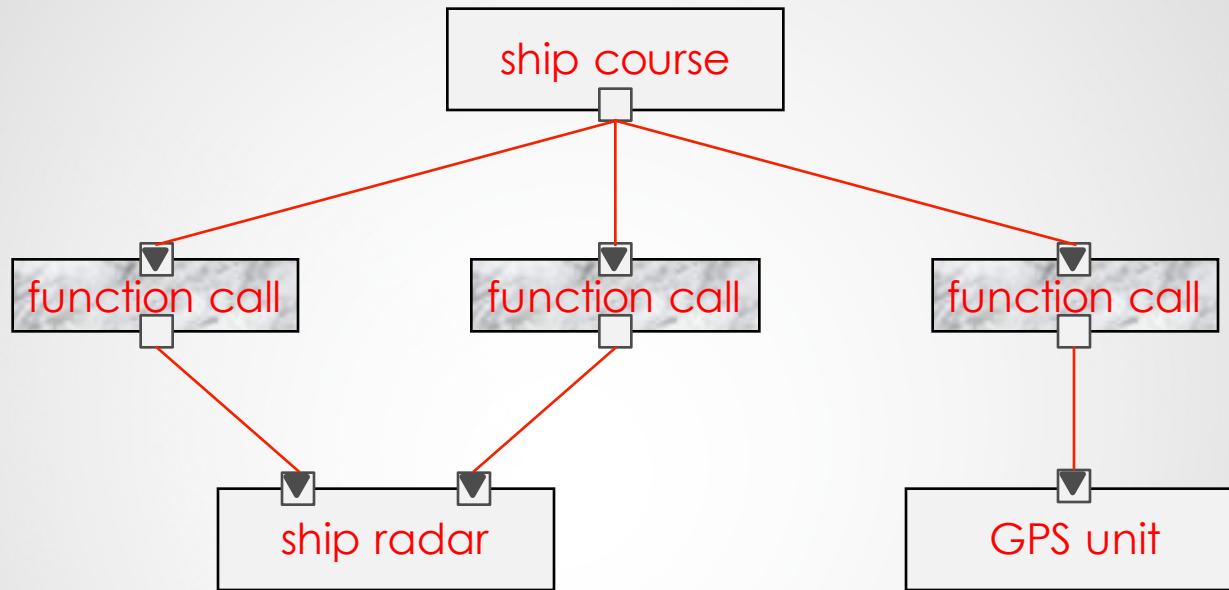
# Other definitions

- Clements, Bass, Kazman: “The set of *structures* needed to *reason about the system*, which comprise software *elements*, *relations* among them, and *properties* of both.”
- Spinellis: “How your whole *system* (in the widest possible sense) will be decomposed into *processes* or *services*; how *data* are *stored*, *communicated*, and *processed*; and how all *parts fit together* to deliver the required *functionality*, *reliability*, *capacity*, *scalability*, *maintainability*, and *portability*.”

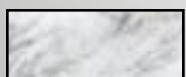
# Other definitions

- Fowler: “The *highest-level* breakdown of a system into its *parts*; the *decisions* that are hard to change.”
- Natarén: “The clear definition of multiple *high-level components* that, when working together, form your *system* and solve your problem.”

# Example configuration

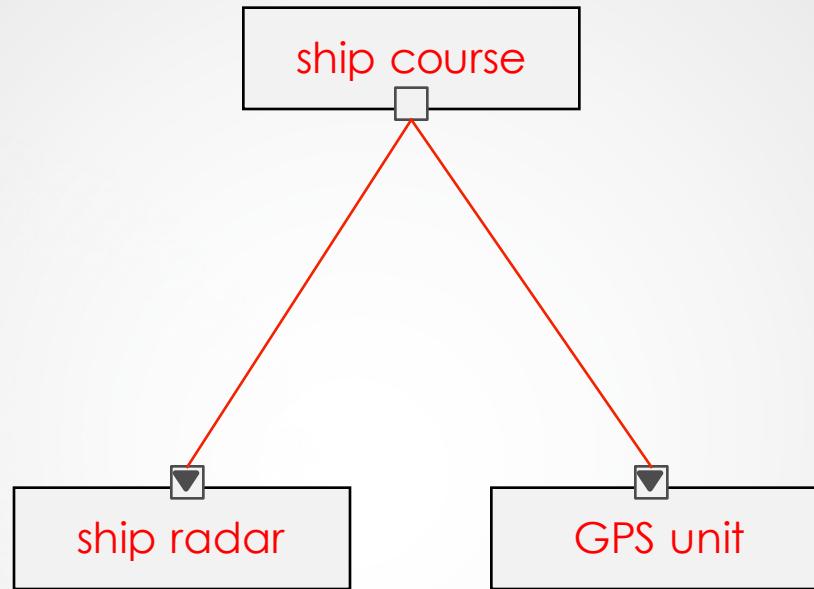


component

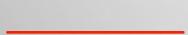


connector

# Example configuration - simplified



component

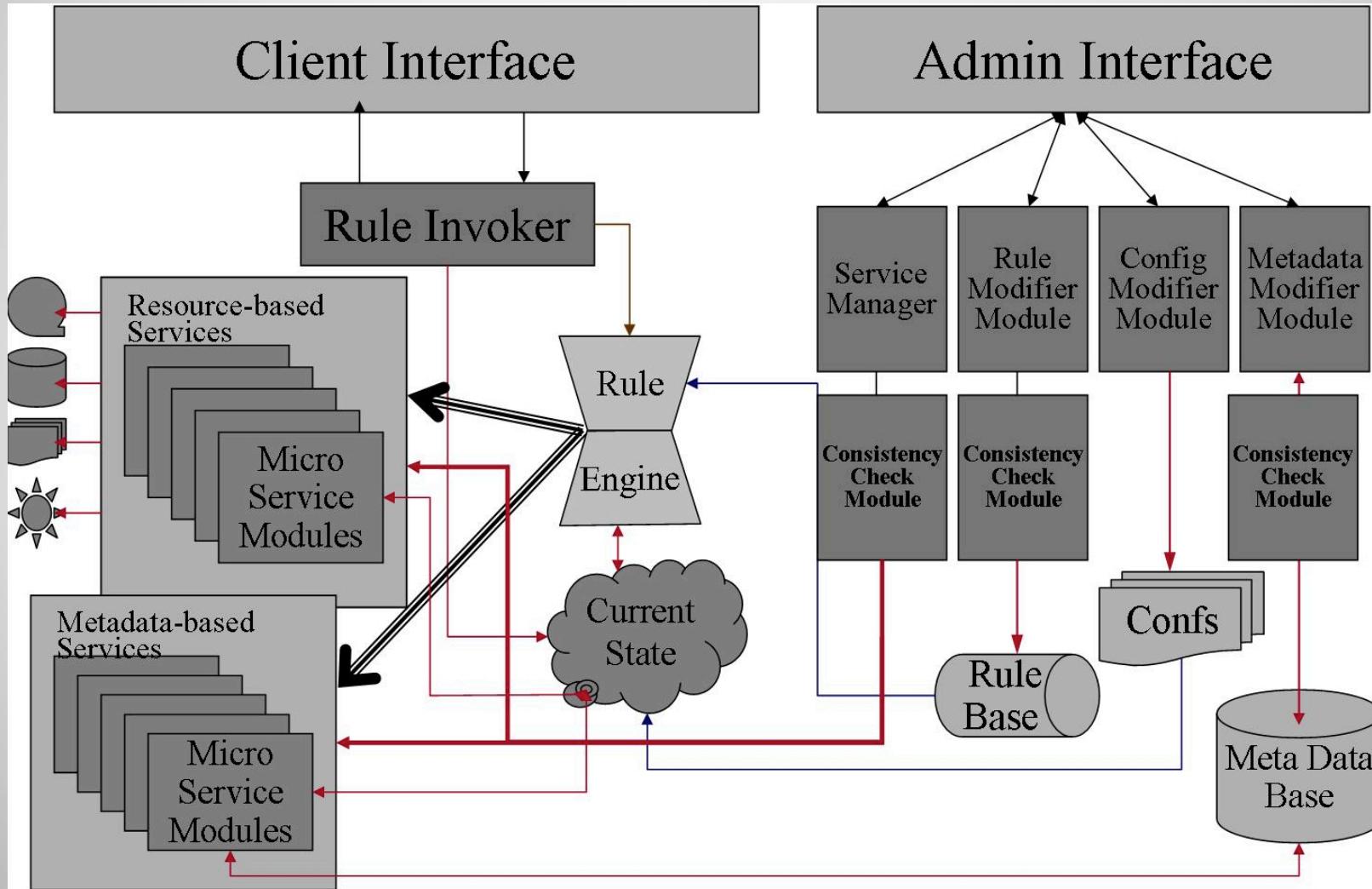


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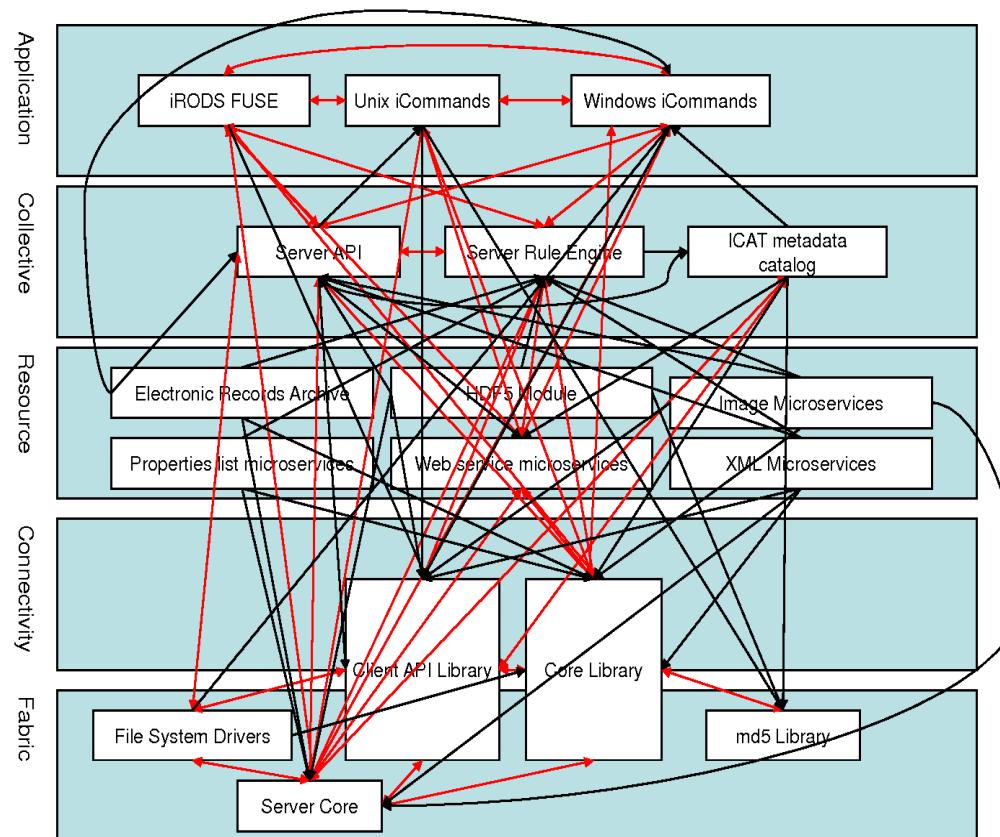
# Architectural erosion

- When a system evolves, ideally its prescriptive architecture is modified first
- In practice, the system – and thus its descriptive architecture – is often directly modified
- Why?
  - developer sloppiness
  - short deadlines
  - lack of (documented) prescriptive architecture
  - code optimizations
  - inadequate techniques or tool support

# iRODS – prescriptive architecture



# iRODS – descriptive architecture



# Today's lecture

- Software architecture - recap
- Architectural styles
- Evolution

# Architectural style



Contemporary:



Arts and Crafts:



# Architectural style?

Classical:



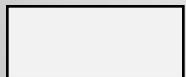
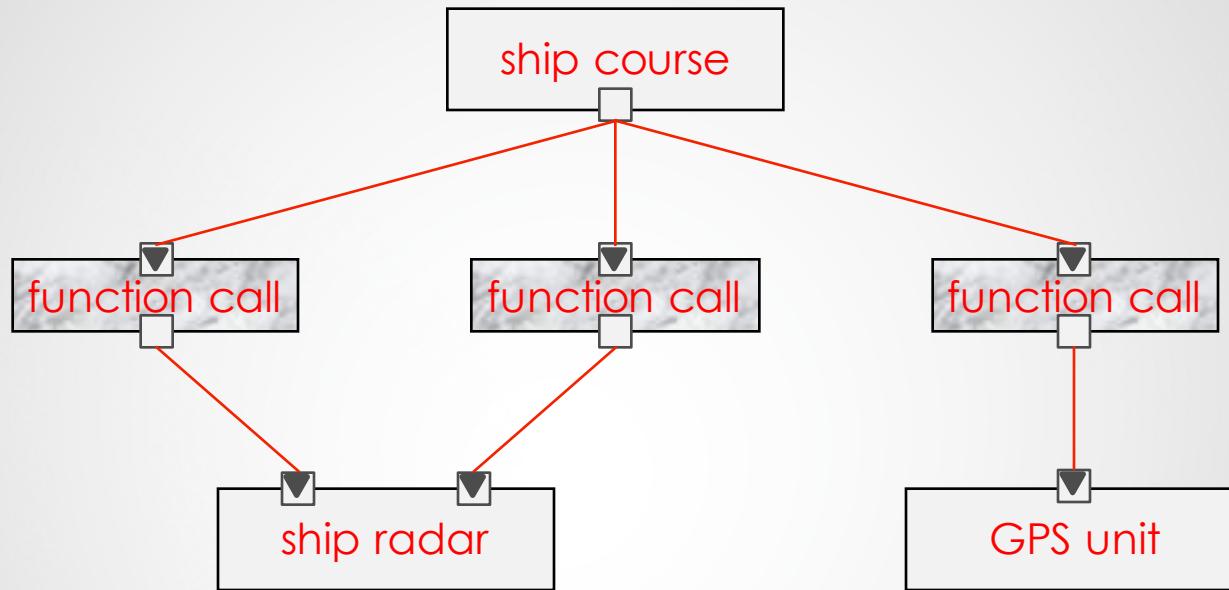
Rock and Roll:



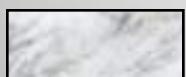
# Architectural style

- A named collection of architectural design decisions that
  - are applicable in a given development context
  - constrain architectural design decisions
  - result in beneficial qualities in each resulting system
- A named, commonly used set of components/connectors/configurations
  - Each component/connector has its own job

# Style 1: object-oriented

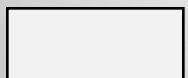
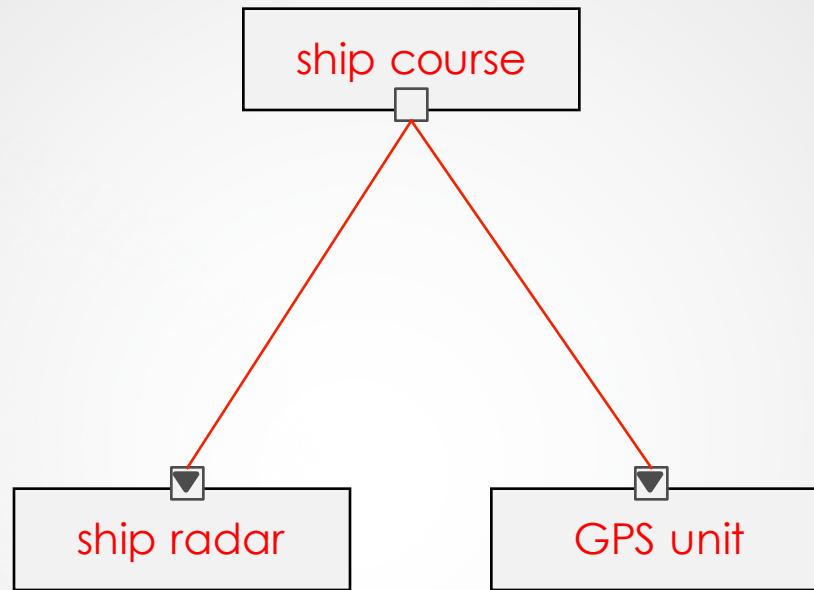


component

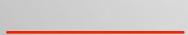


connector

# Style 1: object-oriented (simplified)



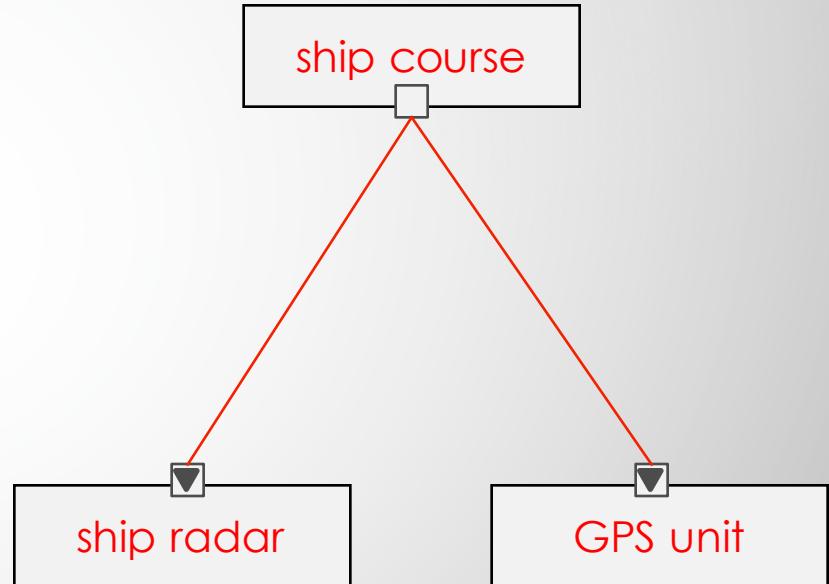
component



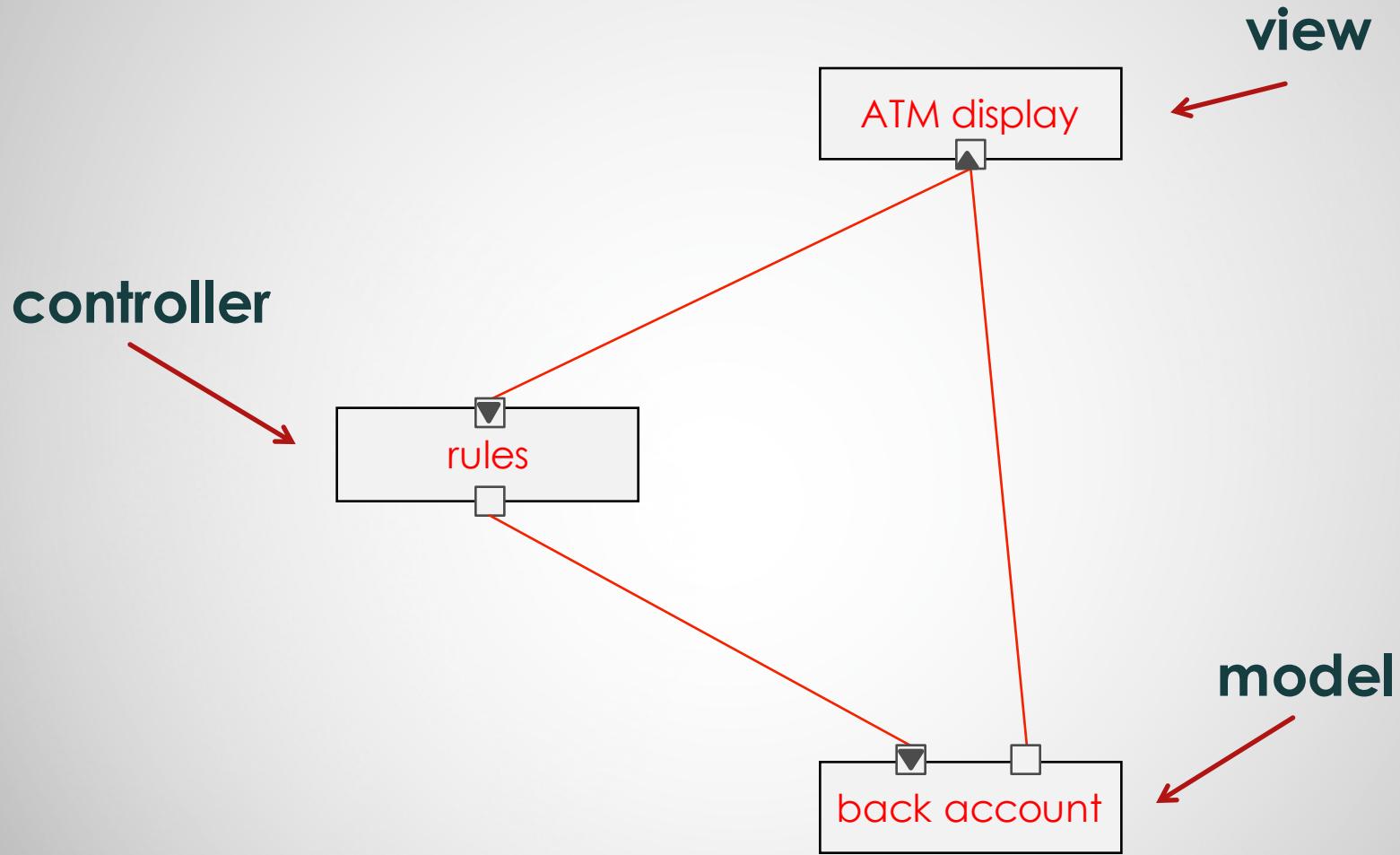
connector

# Style 1: object-oriented

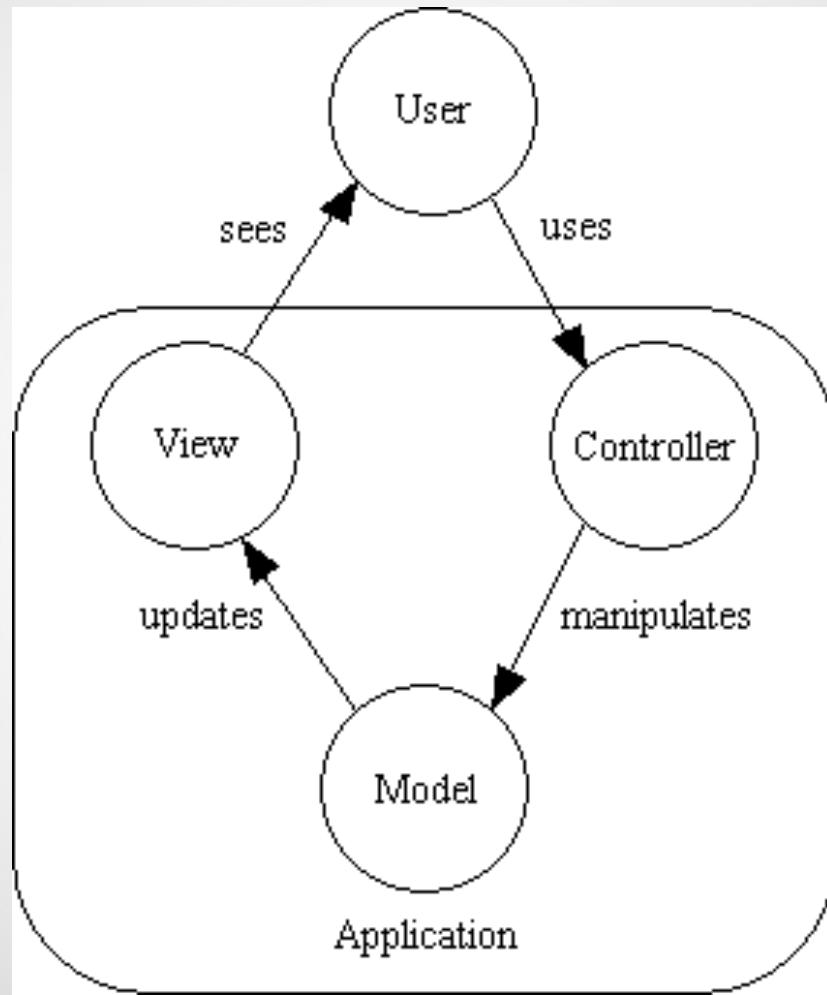
- Key benefits
  - Abstraction
  - Anticipation of change
  - Understandability
- Examples
  - Business applications



# Style 2: model-view-controller

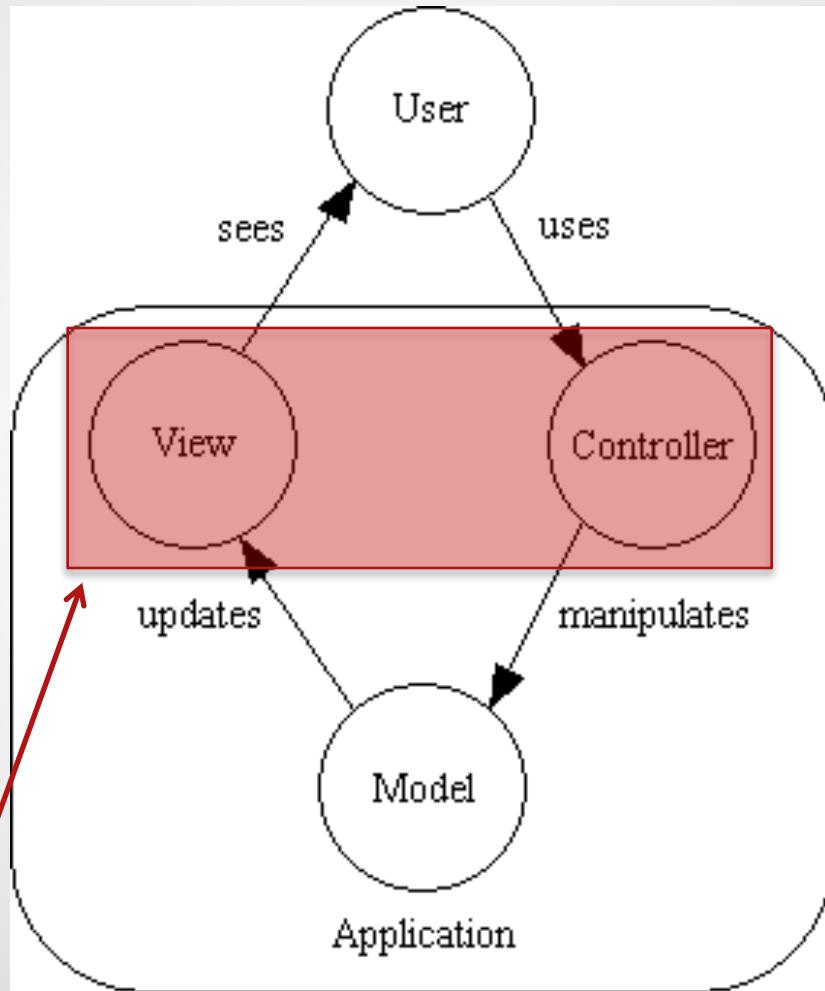


# Style 2: model-view-controller



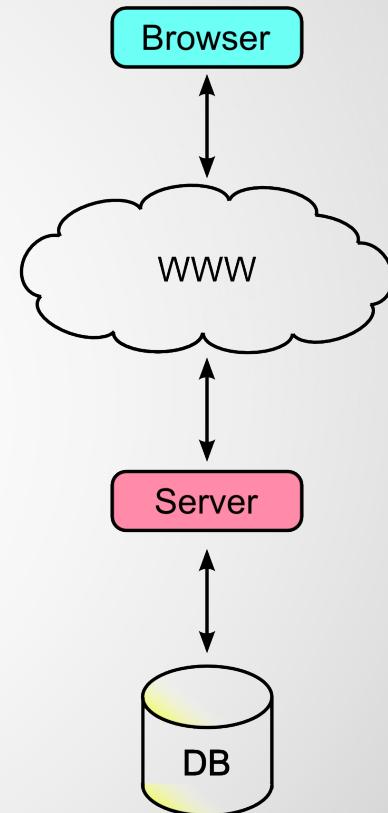
# Style 2: model-view-controller

User interface

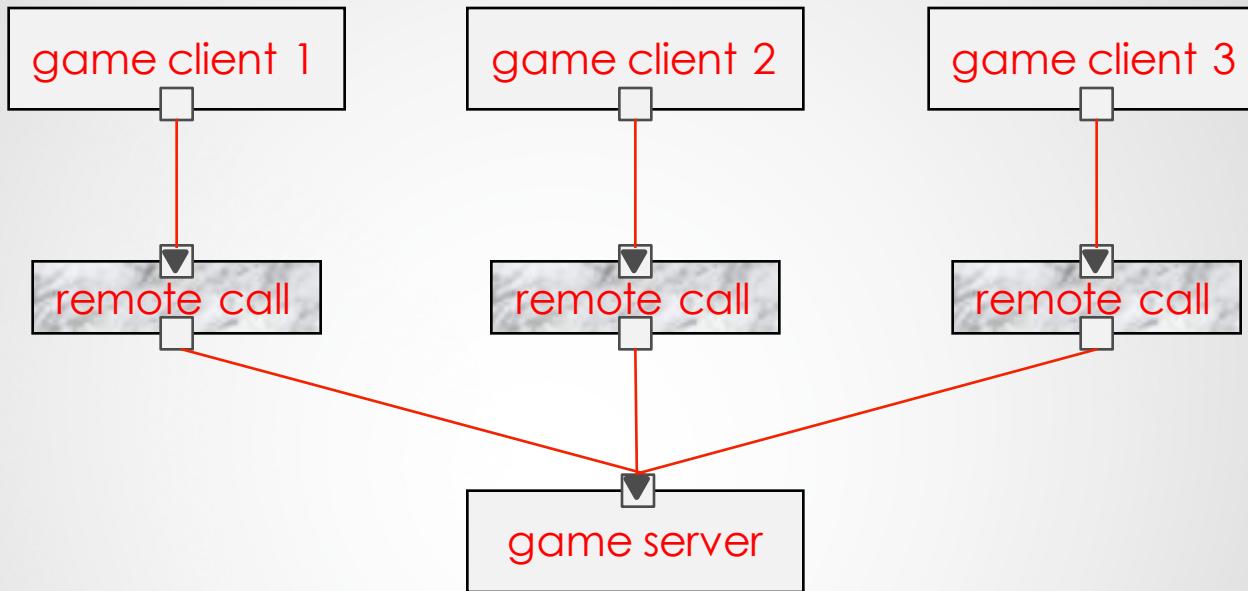


# Style 2: model-view-controller

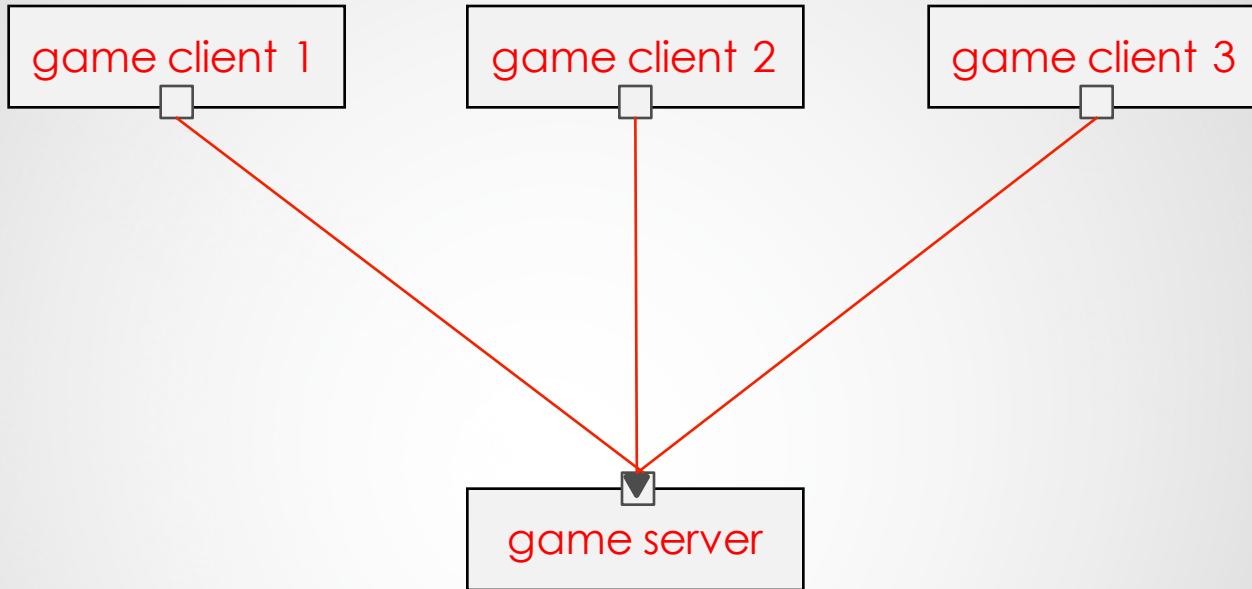
- Key benefits:
  - Modularity
  - Anticipation of change
- Examples
  - Web applications



# Style 3: client-server

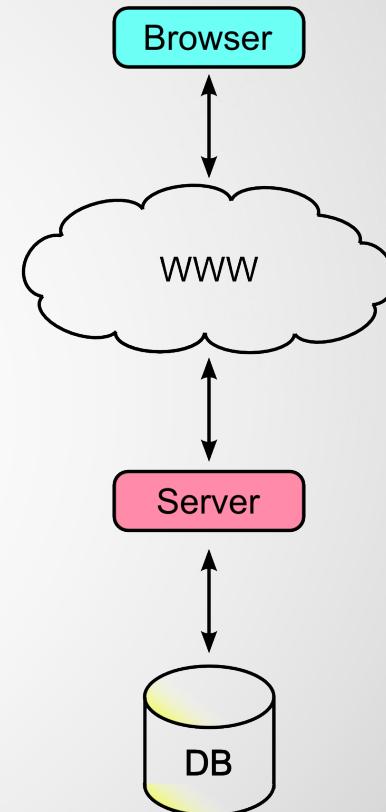


# Style 3: client-server (simplified)



# Style 3: client-server

- Key benefits
  - Centralized control
- Examples
  - email
  - Web browser-based programs



# Style 4: layered



# Style 4: layered (Android)

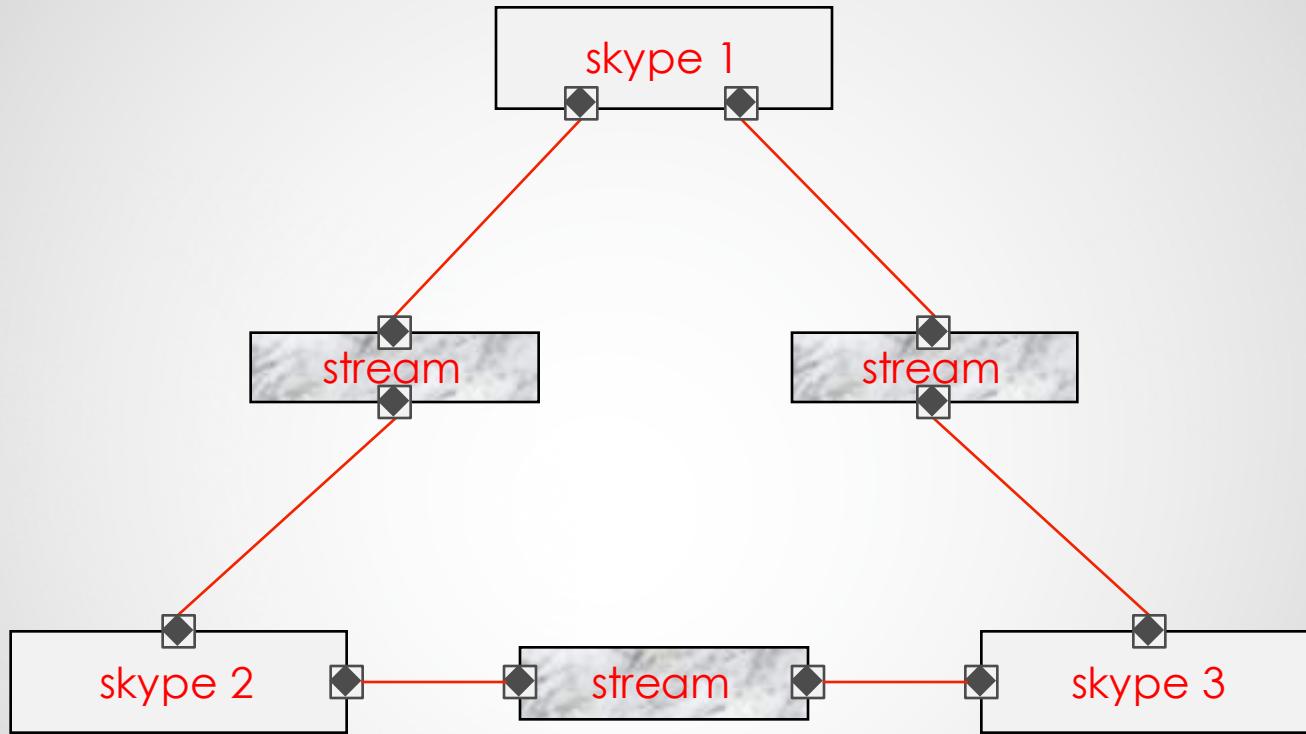


Source: <http://www.zdnet.com/article/how-android-works-the-big-picture/>

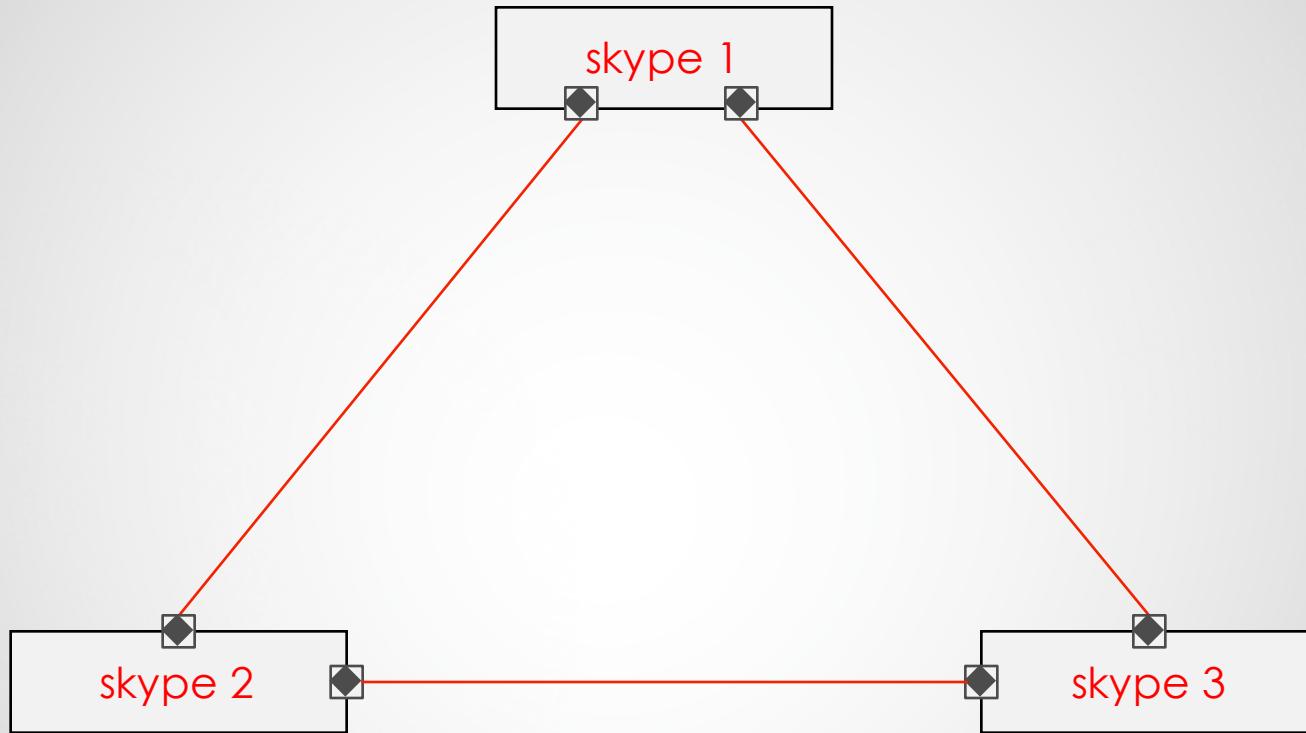
# Style 4: layered

- Key benefits
  - Modularity
  - Abstraction
  - Anticipation of change
  - Reuse
- Examples
  - Operating systems
  - Networks

# Style 5: peer-to-peer



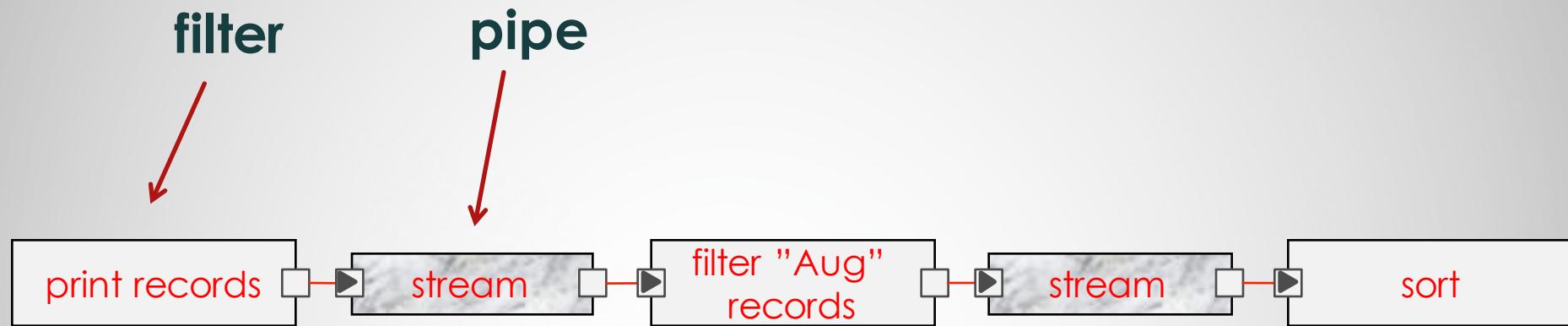
# Style 5: peer-to-peer (simplified)



# Style 4: peer-to-peer

- Key benefits
  - Robustness
  - Efficiency
- Examples
  - File sharing systems
  - Skype, Google Hangouts
  - Internet of Things
  - Bitcoin, Blockchain

# Style 6: pipe-and-filter



```
ls -l | grep "Aug" | sort
```

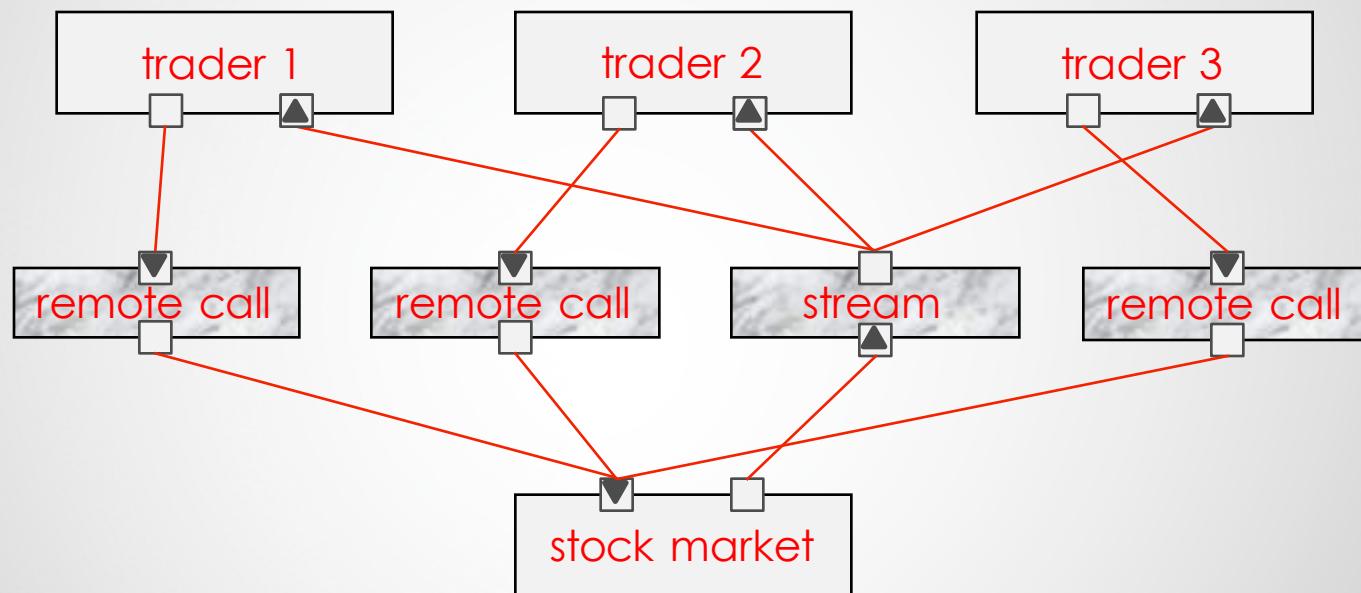
# Style 6: pipe-and-filter



# Style 6: pipe-and-filter

- Key benefits
  - Modularity
  - Reuse
  - Anticipation of change
- Examples
  - UNIX shell
  - Compilers

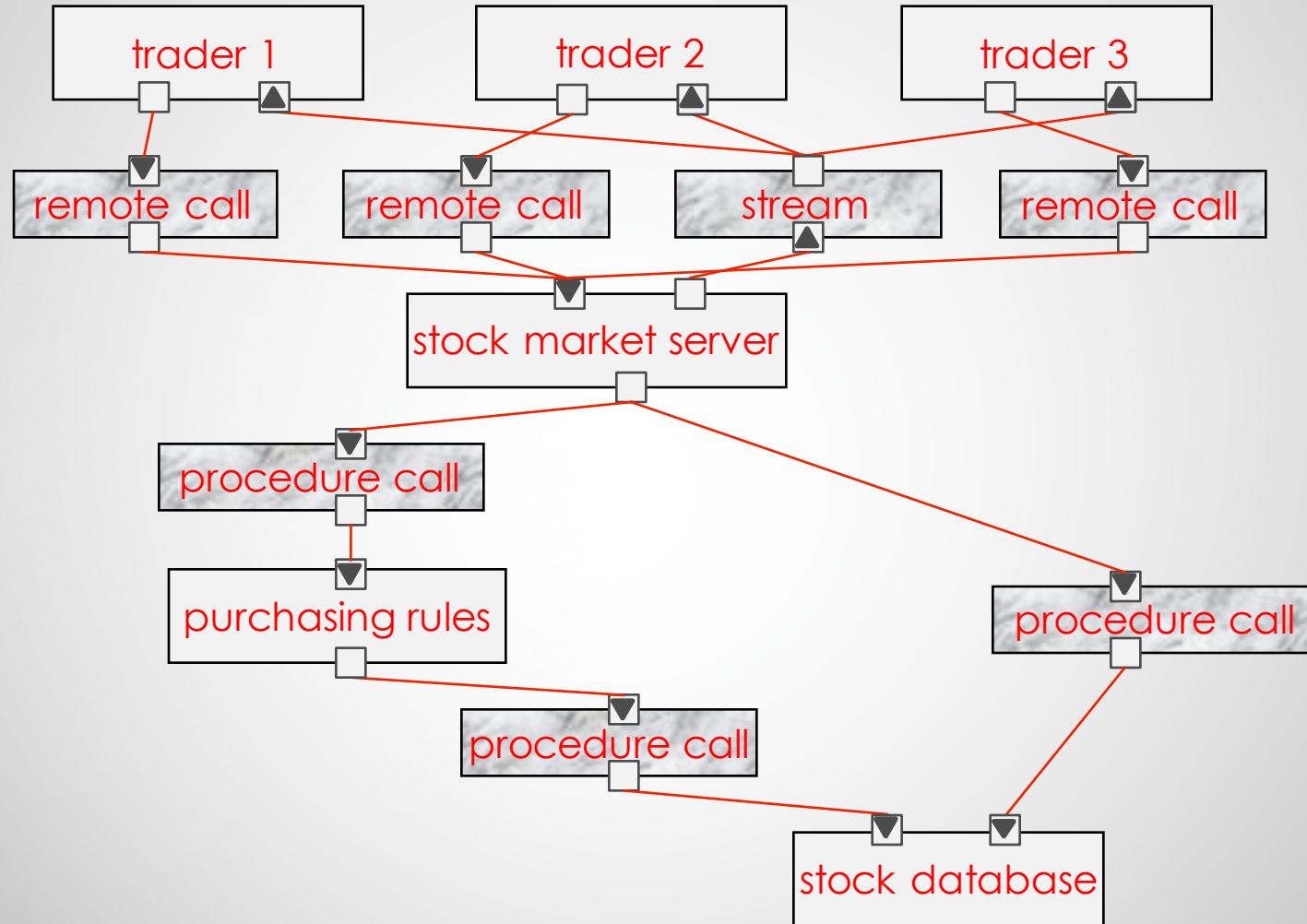
# Style 7: publish-subscribe (“pub-sub”)



# Style 7: pub-sub

- Key benefits
  - Efficiency
  - Scalability
- Examples
  - Stock market
  - News

# Mixing styles is often necessary



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- Architectural styles
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# All successful software evolves

- <https://www.youtube.com/watch?v=oIFEpeMwgHk>
- <https://www.youtube.com/watch?v=zI15BOtX5Pw>

The screenshot shows a web browser window with the URL "info.cern.ch" in the address bar. The main content area displays the "World Wide Web" homepage. The page title is "World Wide Web". Below the title, a paragraph states: "The WorldWideWeb (W3) is a wide-area [hypermedia](#) information retrieval initiative aiming to give universal access to a large universe of documents." A link to an "executive summary" is mentioned. The page is filled with numerous hyperlinks in blue, such as "Mailing lists", "Policy", "W3 news", and "Frequently Asked Questions". A section titled "What's out there?" provides links to "subjects" and "W3 servers". Other sections include "Help" (with links to browser pointers), "Software Products" (with a note about W3 components), "Technical" (with details about protocols), "Bibliography" (with paper documentation), "People" (with a list of project members), "History" (with a history summary), "How can I help?" (with support information), and "Getting code" (with instructions for code retrieval via anonymous FTP). The browser interface includes standard Mac OS X window controls (red, yellow, green buttons) and a toolbar with icons for back, forward, search, and refresh.

# World Wide Web

The WorldWideWeb (W3) is a wide-area [hypermedia](#) information retrieval initiative aiming to give universal access to a large universe of documents.

Everything there is online about W3 is linked directly or indirectly to this document, including an [executive summary](#) of the project, [Mailing lists](#) , [Policy](#) , November's [W3 news](#) , [Frequently Asked Questions](#) .

[What's out there?](#)

Pointers to the world's online information, [subjects](#) , [W3 servers](#), etc.

[Help](#)

on the browser you are using

[Software Products](#)

A list of W3 project components and their current state. (e.g. [Line Mode](#) ,[X11 Viola](#) ,[NeXTStep](#) ,[Servers](#) ,[Tools](#) ,[Mail robot](#) ,[Library](#) )

[Technical](#)

Details of protocols, formats, program internals etc

[Bibliography](#)

Paper documentation on W3 and references.

[People](#)

A list of some people involved in the project.

[History](#)

A summary of the history of the project.

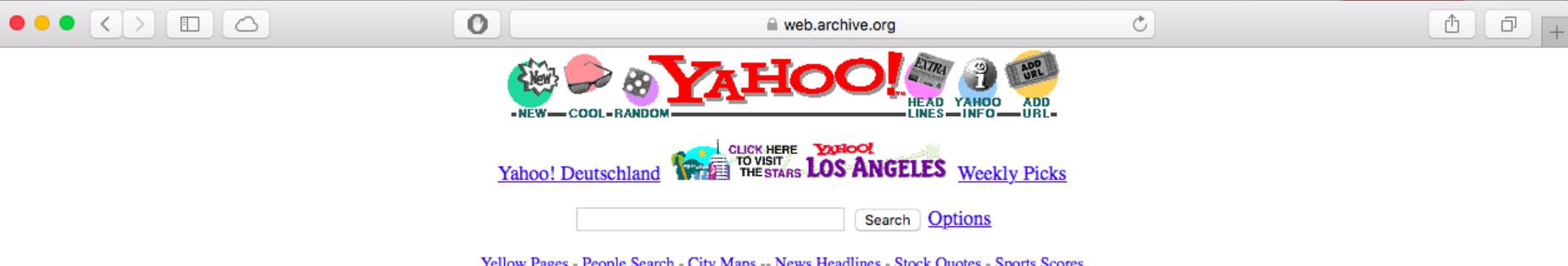
[How can I help ?](#)

If you would like to support the web..

[Getting code](#)

Getting the code by [anonymous FTP](#) , etc.

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<b>Aliweb</b> <input type="text"/> <input type="button" value="Search"/> <input type="button" value="Reset"/>	
<b>ADVANCED OPTIONS:</b> Case Sensitive: <input type="checkbox"/> Display Fields Other Than Title? <input checked="" type="checkbox"/> Description <input type="checkbox"/> Keyword <input type="checkbox"/> URL <input type="checkbox"/> Other Select Search Fields <input checked="" type="checkbox"/> Title <input checked="" type="checkbox"/> Description <input checked="" type="checkbox"/> Keyword <input checked="" type="checkbox"/> URL Limit Results To: 20 matches <input type="button" value="▼"/> Restrict to Domain: none <input type="button" value="▼"/> Search Type: Whole Words <input type="button" value="▼"/> Record Type: Any <input type="button" value="▼"/>	
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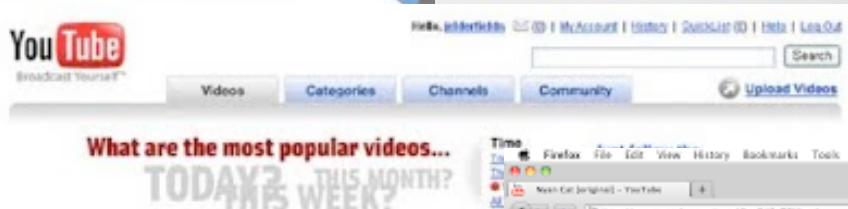
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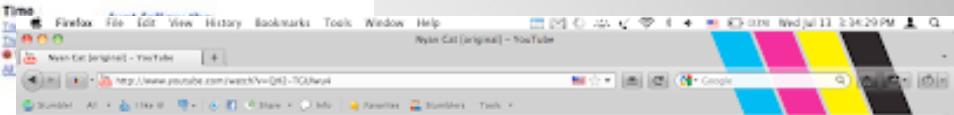
2005



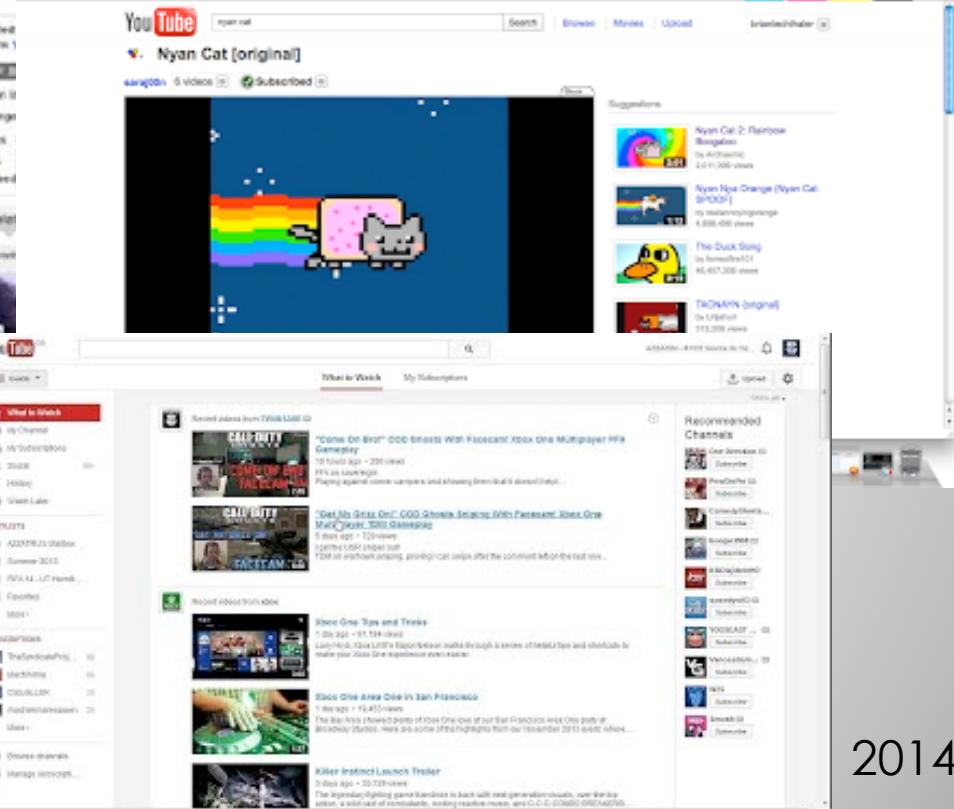
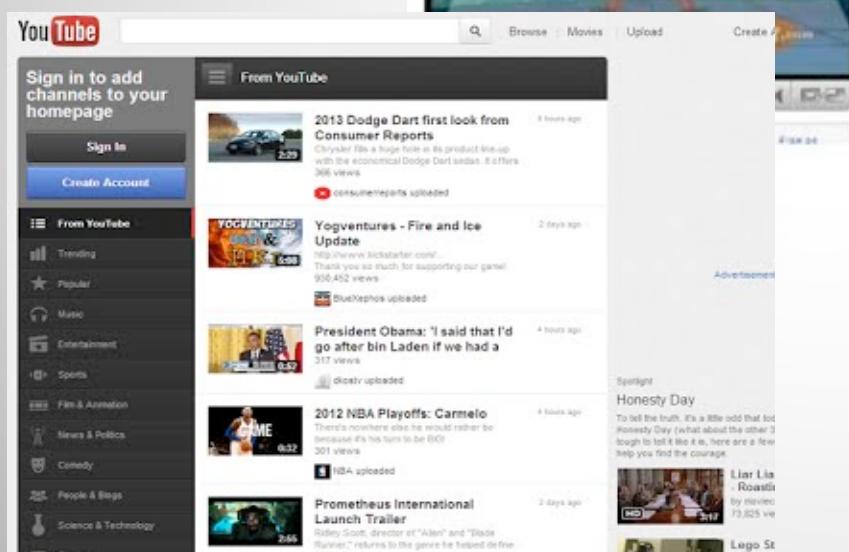
2007



2011



2012



2014

# Netflix

## Monthly Streaming Hours

Dec 2007-Dec 2015  
>>1,000x growth

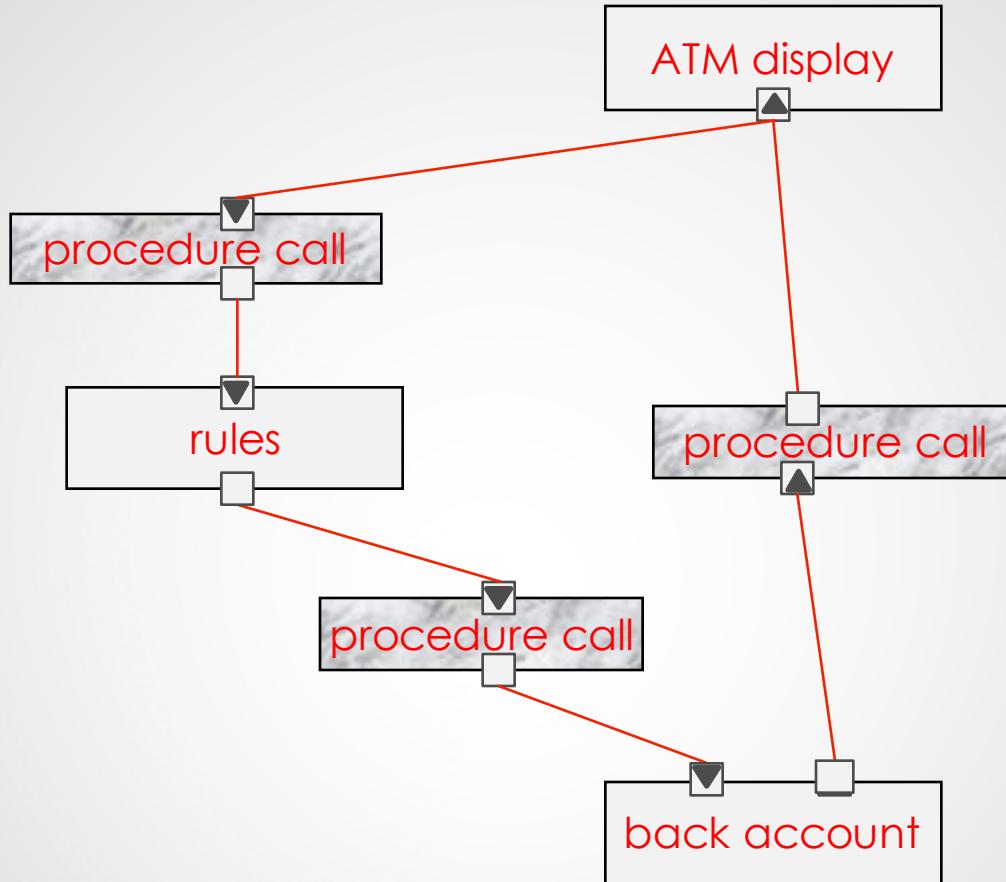


# Evolution

- All successful software evolves!
- Essential part of software development
- Must be accommodated/planned as much as possible

Architecture is a key tool in accommodating evolution

# Accommodating change



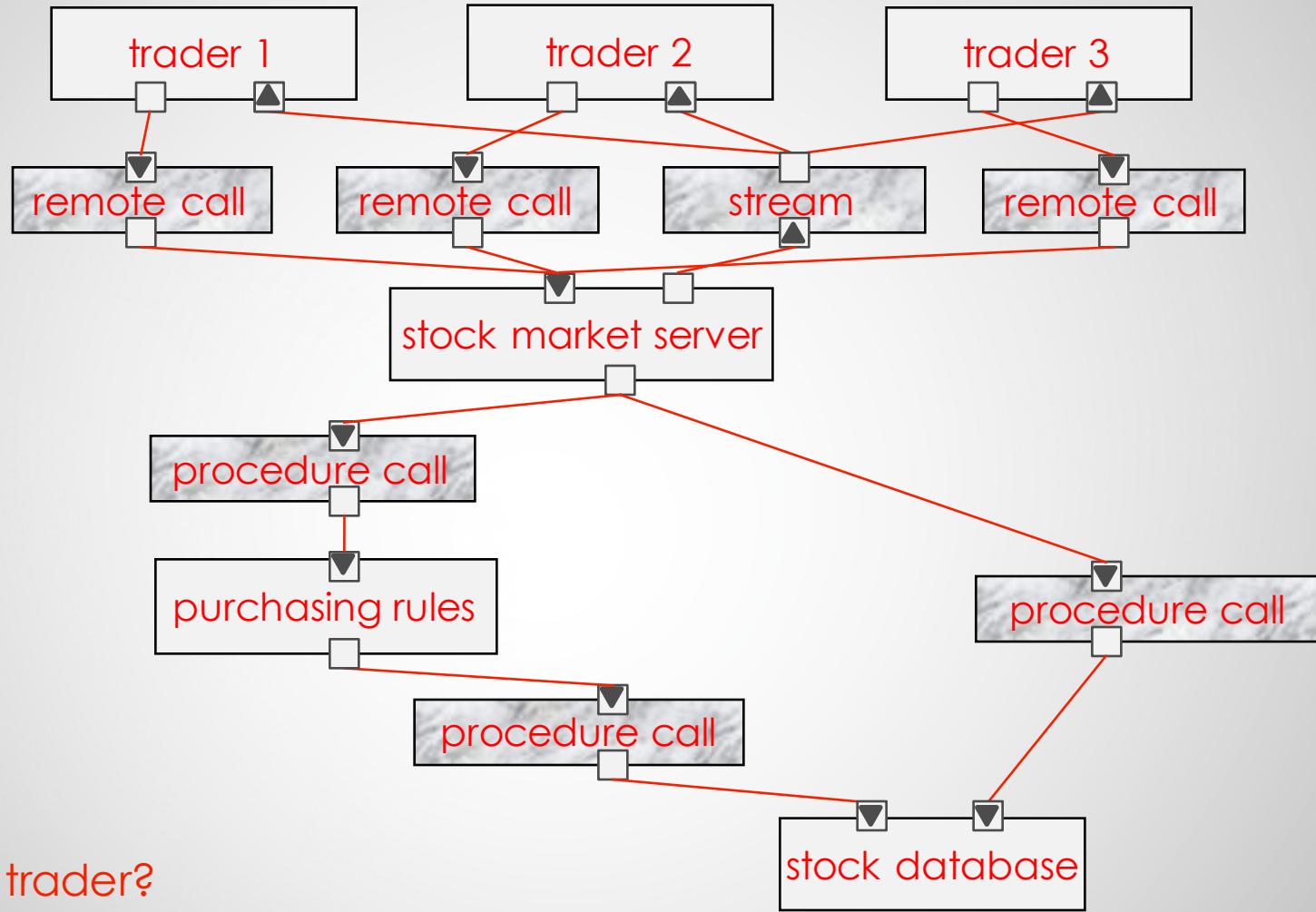
New overdraft rule?

# Accommodating change?

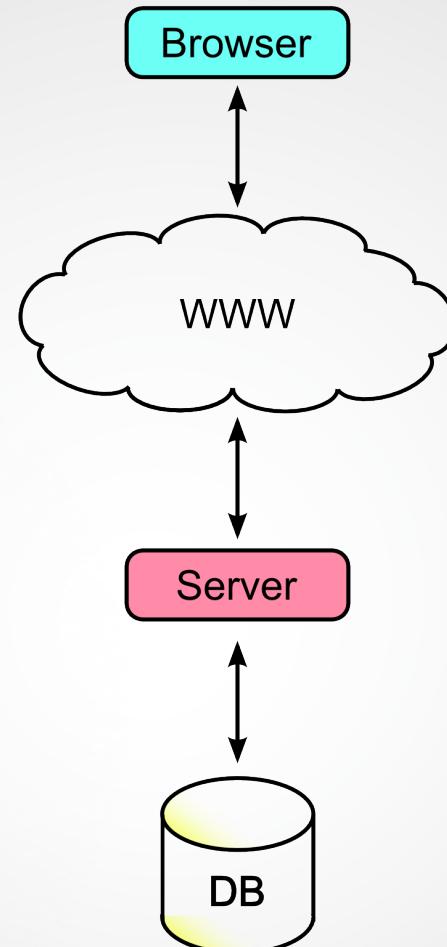


Only records with names starting with A-L?

# Accommodating change

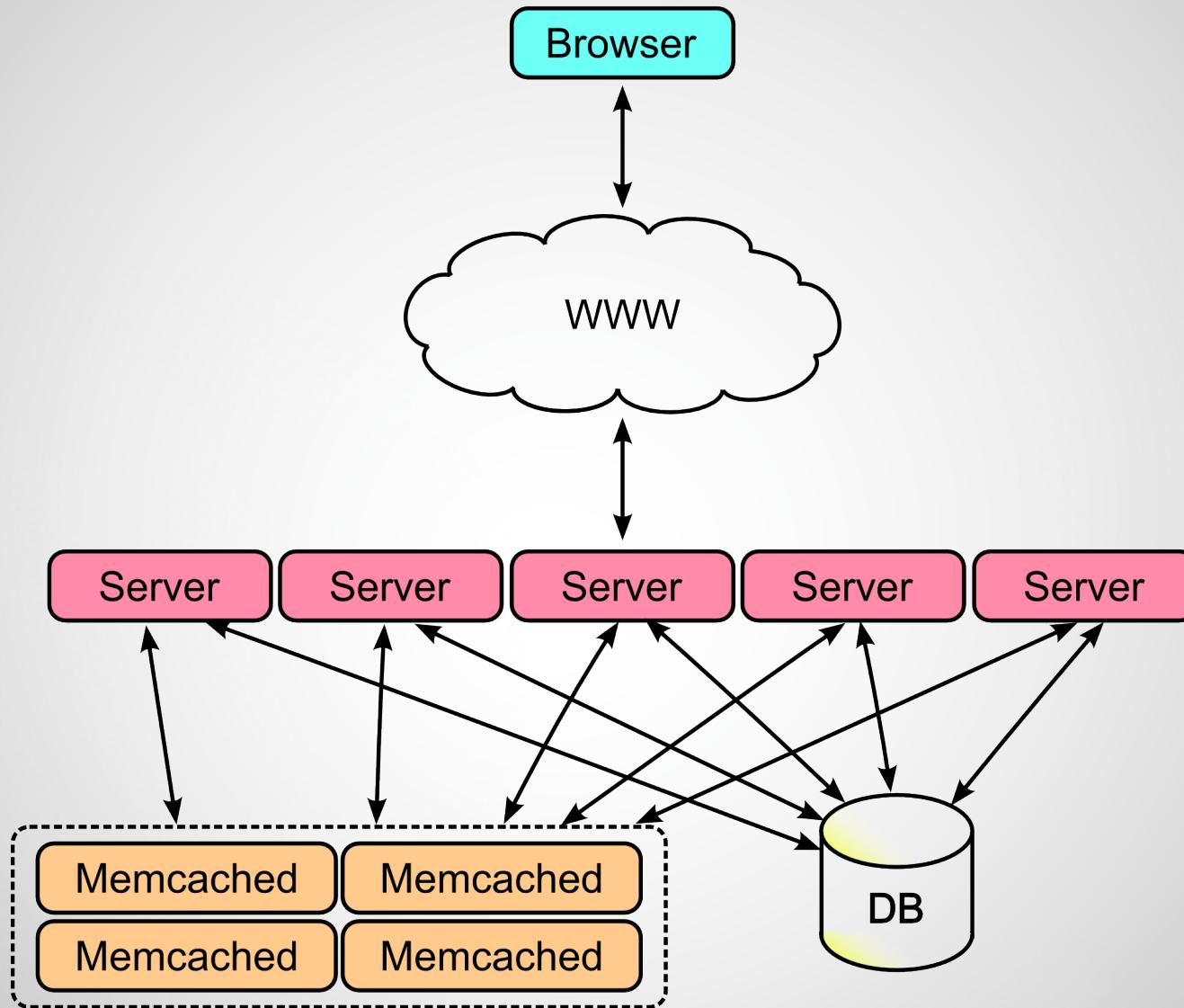


# Accommodating change



More users?

# Accommodating change



# Summary

- An architectural style is
  - a named collection of architectural design decisions that result in beneficial qualities in each resulting system
- Styles: object-oriented, model-view-controller, client-server, layered, peer-to-peer, pipe and filter, pub-sub
  - (These are not all the styles that exist)
- All successful software evolves
  - We must plan for this
  - Architecture helps us do so

# Midterm

- Next Tuesday, May 3<sup>rd</sup>
- Seating chart will be posted on doors and inside classroom
- 80 minutes long
- Bring a pencil or two and your ID
- Closed book, closed notes
- You can leave when you are finished
- Show your ID card to one of the teaching staff
- Exit only through the two doors at the bottom of the classroom
- Part multiple-choice, part short/long answer
- Advice: read questions carefully, re-read your answer and check whether it clearly says what you mean, don't rush out at the end

# Midterm Studying

- Lectures
- Things I told you to study for quizzes
- Quizzes
- Readings
- Discussion assignments

# Midterm Studying

Consider the “buy a product scenario.” Which of the following would be an exception flow?

Customer is a premier member

Customer chooses to pay via PayPal

**Customer's credit card is declined**

Customer chooses to use saved shipping/billing info

Customer chooses to use shipping/billing info different from saved info



Draw and label a use case diagram for an online shopping site. Give an example of an exception flow for at least one of your use cases, and describe the condition that would result in that flow.

# Midterm Studying

On the Unix or Linux command line, you can start with a file of records, then filter them, sort them, and remove duplicate records. This architectural style is called

- Filter-and-pipe
- Publish-subscribe
- Pipe-and-filter**
- Layered
- None of the above



Draw and label a diagram of the pipe-and-filter architectural style. Describe one of its benefits.

# Next time

- Midterm review
- Homework 1 due tonight 11:55pm
  - Use format given in template and include scoring sheet!!
  - Late policy: 50% deduction from score if late, drop box closed at 5pm tomorrow