Master-Builders Have Rich Conceptual Models of Software Design

George Fairbanks

22 May 2012

Rhino Research
Software Architecture Consulting and Training

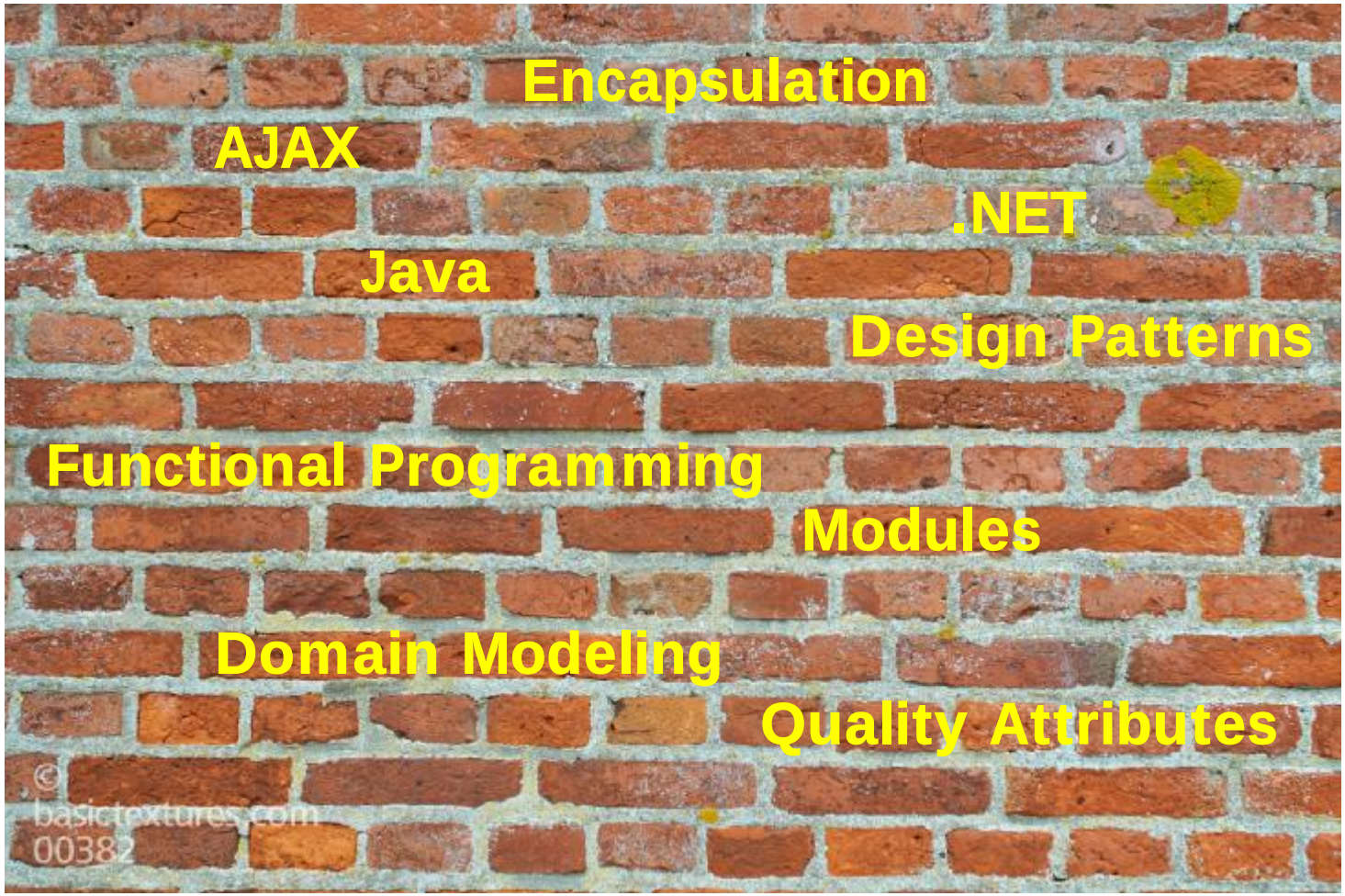
Letter to your 20-year-old self

- You would like to be a master-builder, fast
- What would you tell the younger you?

Roman engineers

- We are no smarter today
- … but kids can do better than the best 2000 years ago
- Partly: better materials; mostly: better concepts
- Today, we teach an improved conceptual model

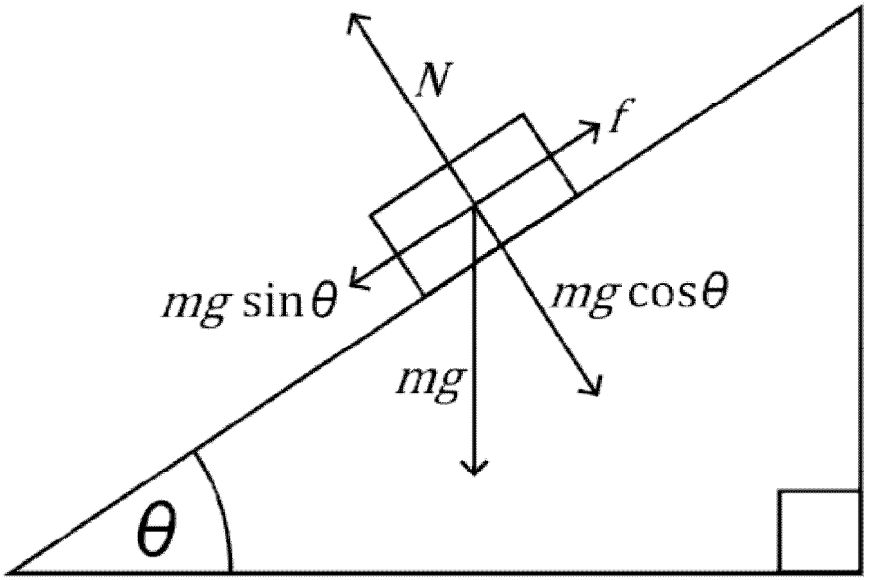
Our knowledge is like a wall



- Easy to describe the bricks
- Conceptual model is the cement

What is a conceptual model?

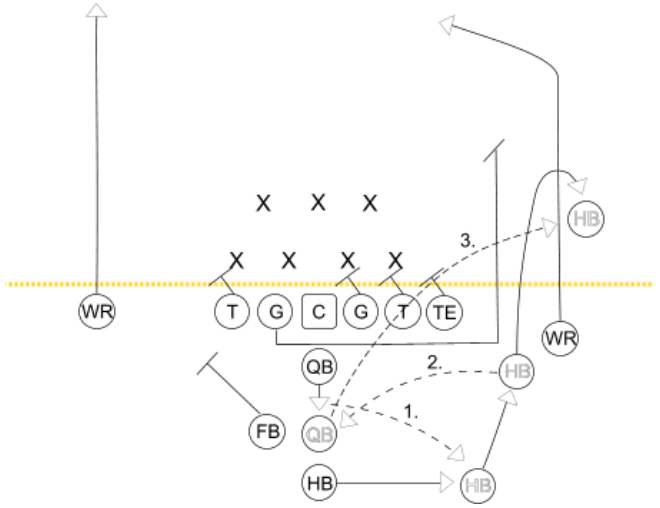
- **What is a conceptual model?**
  - **A conceptual model is a set of concepts that can be imposed on raw events to provide meaning and structure.**
- **It organizes chaos**
  - **Enables intellectual understanding**
  - **Fits big problems into our finite minds**
- **Synonyms:**
  - **Conceptual framework**
  - **Mental model**



Without conceptual models

- Traveling to new countries
  - Everything is harder
  - You didn't become stupid
  - ... but your conceptual model doesn't work
- Fighting with bureaucracy
  - No understanding of the system or how to navigate it
  - Not clear if it has principles or if you are ignorant
- The program crashes because it gets tired
- It won't rain
  - Perhaps doing a dance will make it rain
  - If not, try throwing virgins into volcanoes
- With conceptual model
  - Dancing, rain, virgins, and volcanoes are not causally related

Example: Sports

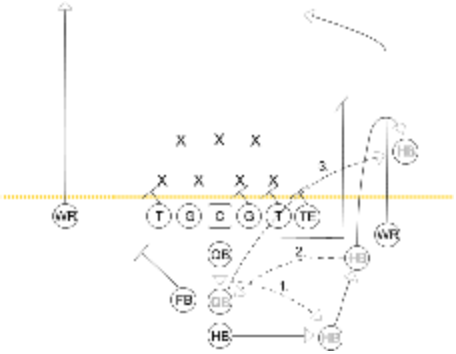


Plays, strategies, assignments

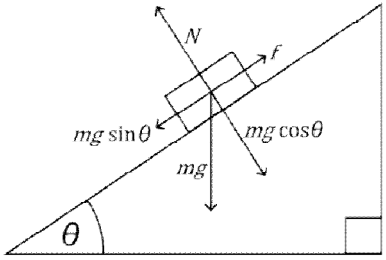
- **Things you cannot see or touch are important**
- **Conceptual models bring their own vocabulary**

Example: Dandelions

Examples of conceptual models

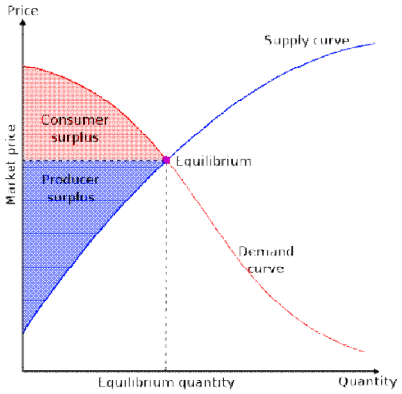


Sports: Plays, strategies, assignments



Physics: Free Bodies

Energy cycle



Econ: Supply & demand

Accounting: Debits & credits

With a conceptual model

So, what is it exactly?

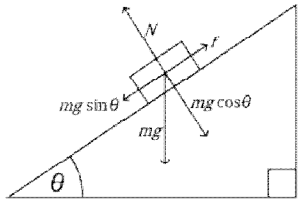
- We want a conceptual model of software design

- ... what might that look like?

Source 1: Software architecture

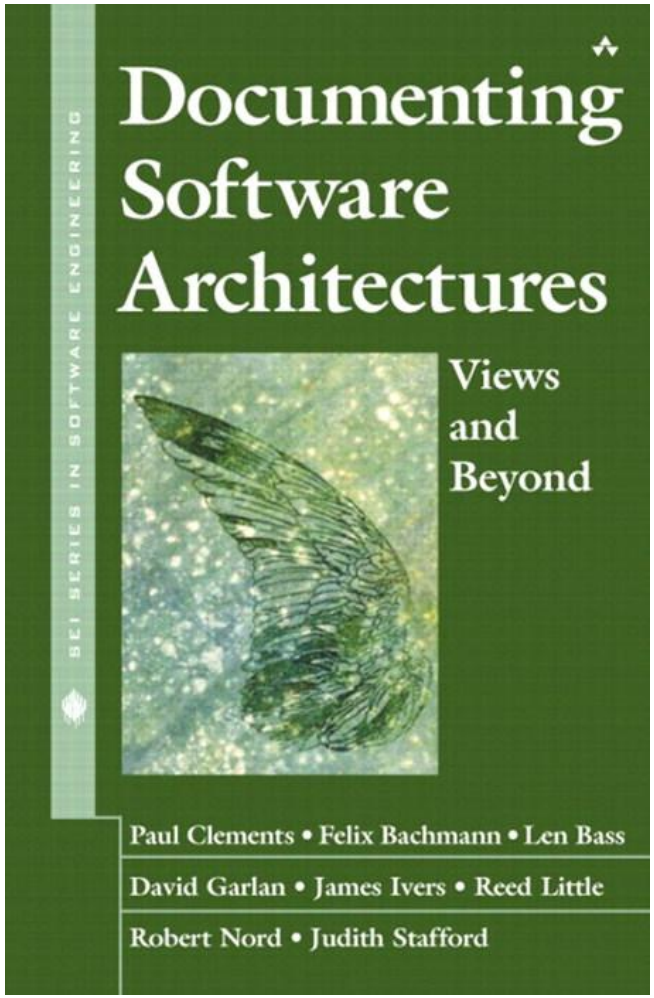
- Model relationships
  - Views & viewtypes
  - Designation
  - Refinement
- Canonical model structure
  - Domain model
  - Design model
    - Recursively
  - Code model
- Quality attributes
- Design decisions
- Tradeoffs
- Responsibilities
- Constraints (guide rails)

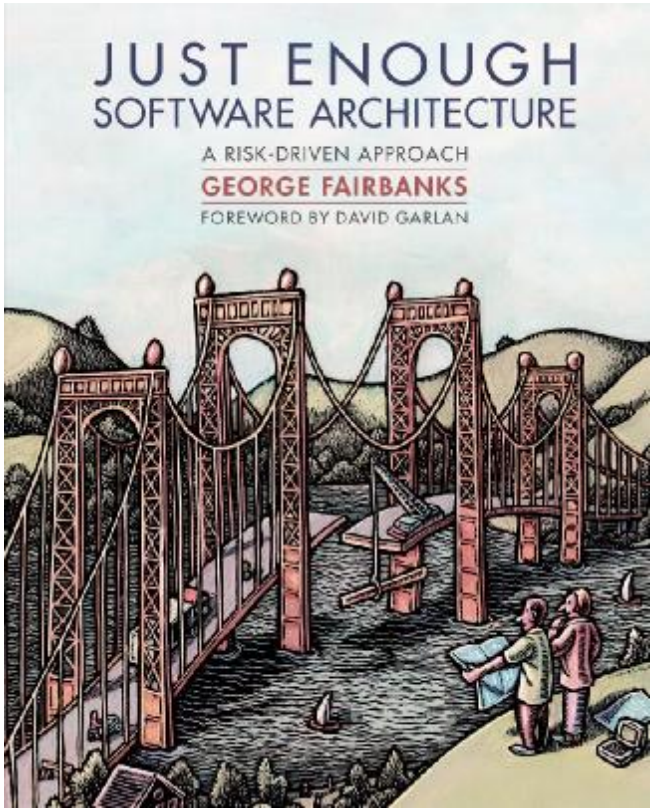
- Viewtypes
  - Module
  - Runtime
  - Allocation



- Module viewtype
  - Modules
  - Dependencies
  - Nesting
- Runtime viewtype
  - Components
  - Connectors
  - Ports
- Allocation viewtype
  - Environmental element
  - Communication channels

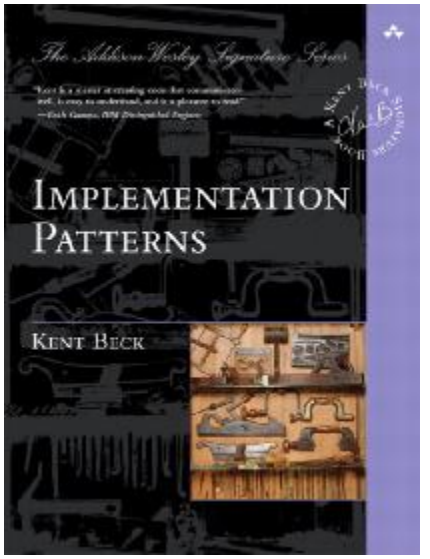
Where to learn it?





Source 2: Kent Beck's model

- **Hierarchy: Values à Principles à Patterns**
- **Values:**
  - **Communication, simplicity, flexibility**
- **Principles:**
  - **Local consequences, minimize repetition, minimize repetition, logic and data together, symmetry, declarative expression, rate of change**
- **Note: no named abstractions**
  - **E.g., modules, dependencies, …**



Source 3: Jeff Dean's "model"

Numbers Everyone Should Know

L1 cache reference	0.5 ns
Branch mispredict	5 ns
L2 cache reference	7 ns
Mutex lock/unlock	25 ns
Main memory reference	100 ns
Compress 1K bytes with Zippy	3,000 ns
Send 2K bytes over 1 Gbps network	20,000 ns
Read 1 MB sequentially from memory	250,000 ns
Round trip within same datacenter	500,000 ns
Disk seek	10,000,000 ns
Read 1 MB sequentially from disk	20,000,000 ns
Send packet CA->Netherlands->CA	150,000,000 ns

Google

- **Jeff Dean, LADIS 2009 keynote**

Interrogation by David Garlan

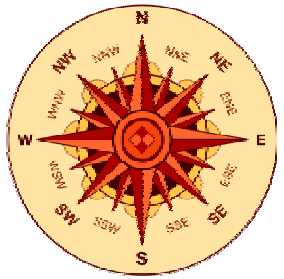
- Yearly software architecture class at Carnegie Mellon
- David interrogates students at end of semester

- Invariably:
  - David catches mistakes in reasoning (connections)
  - David finds holes (absence)

- Lessons
  1. Conceptual model is teachable
     - Even though David knew it better
  2. A conceptual model is helpful
     - Students know the “bricks” better than David
  3. Knowing the abstractions is not enough
     - They are themselves bricks (recursive!)

Conclusion

- **Invisible, colorless, odorless**
  - **Conceptual models are easy to miss**
- **Conceptual models**
  - **Key difference between novice and expert**
- **Become a master builder**
  - **Study the software architecture field**
- **What would you write in a letter to a younger you?**
  - **Hard question: how do we express that knowledge?**



About me (George Fairbanks)

- PhD Software Engineering, Carnegie Mellon University
- Thesis on frameworks and static analysis (Garlan & Scherlis advisors)
- Program chair: SATURN 2012; Program committee member: WICSA 2009, ECSA 2010, ICSM 2009; CompArch 2011 local chair
- Architecture and design work at big financial companies, Nortel, Time Warner, others
- Teacher of software architecture, design, OO analysis / design

- Author: ***Just Enough Software Architecture***