A Design Perspective on Modularity

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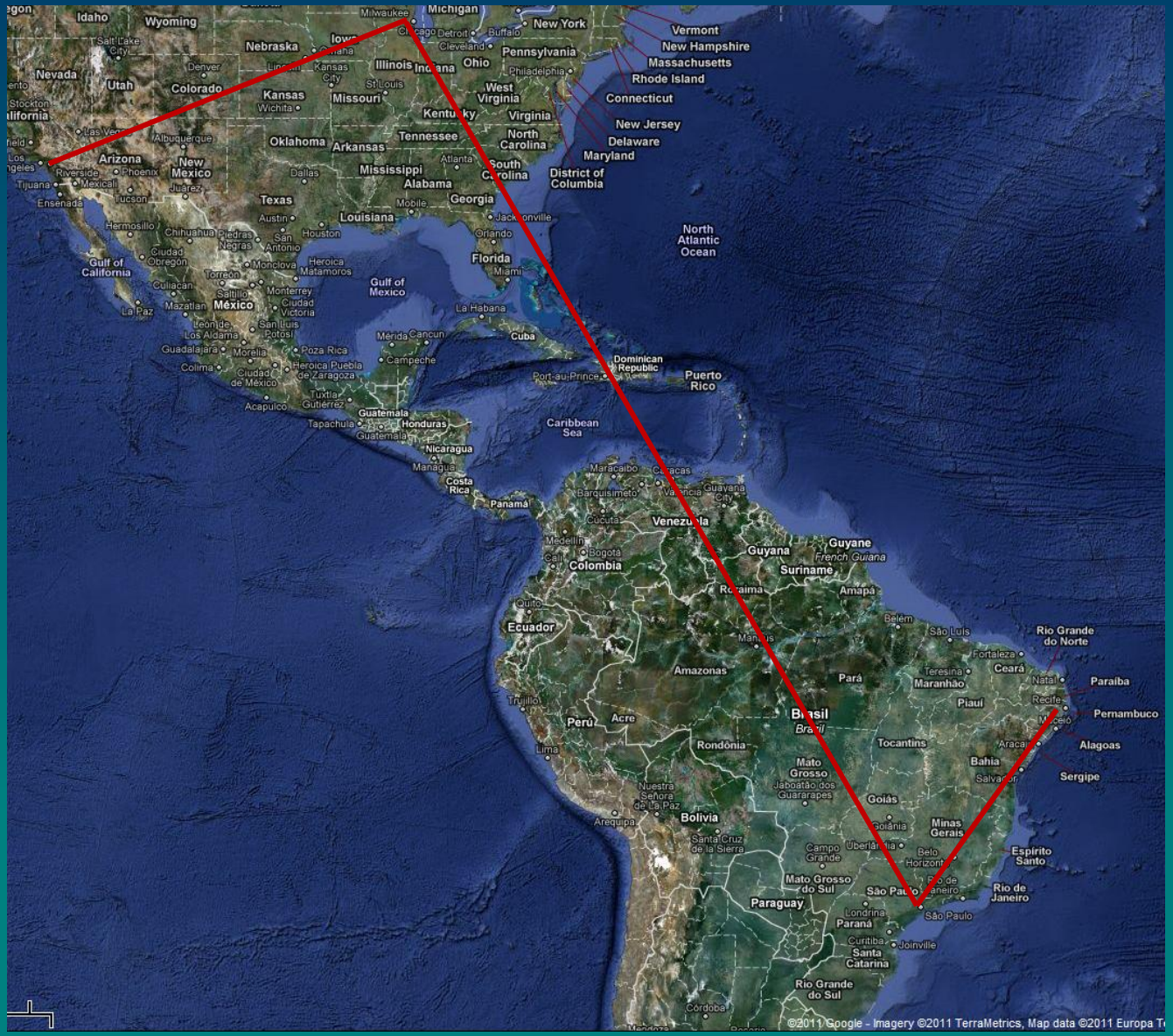
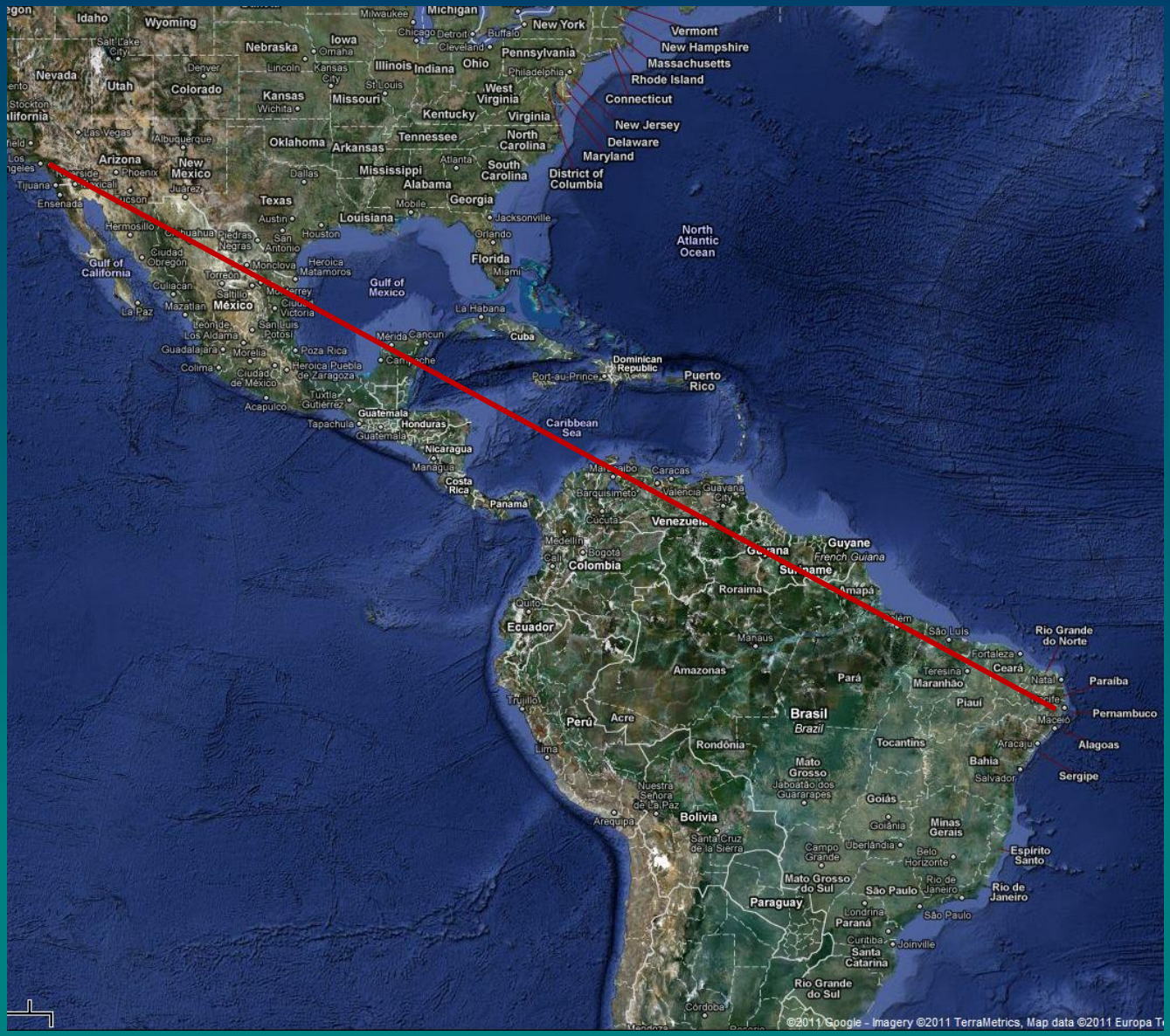
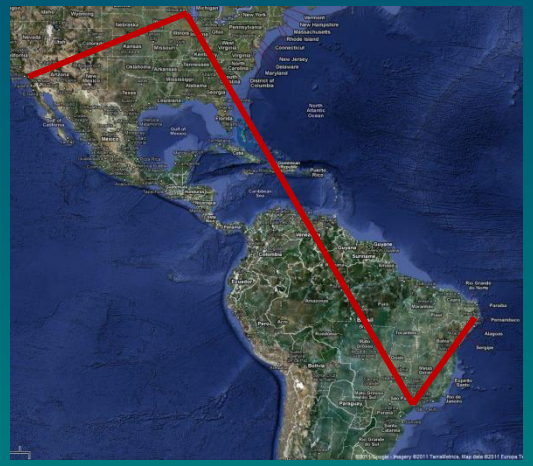
A Brief Nod…

A Modular System



A Modular System





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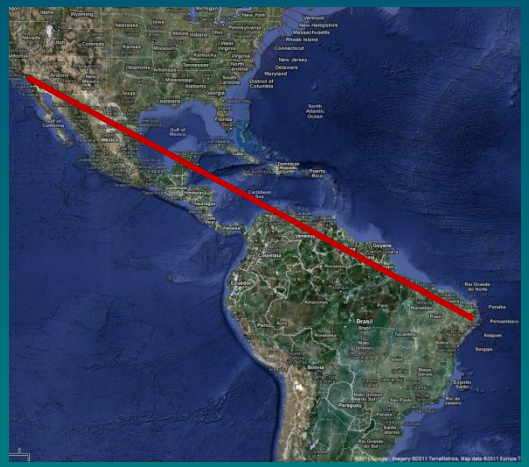

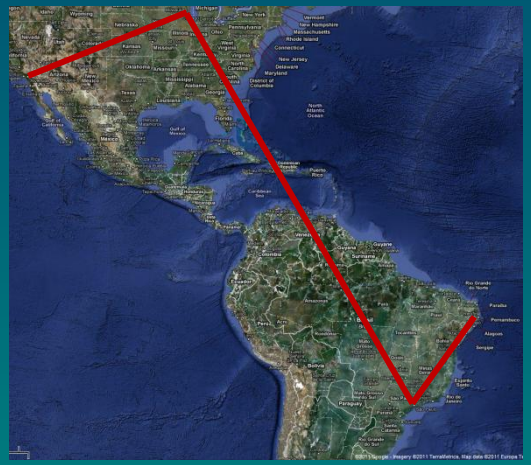

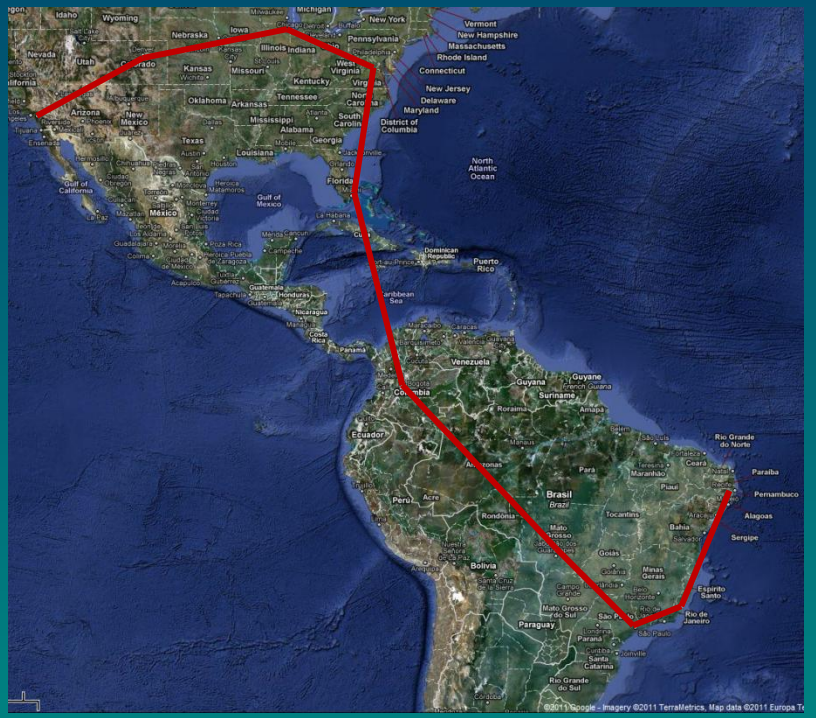

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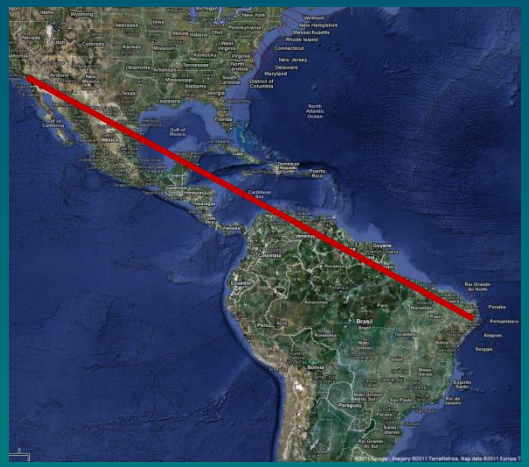

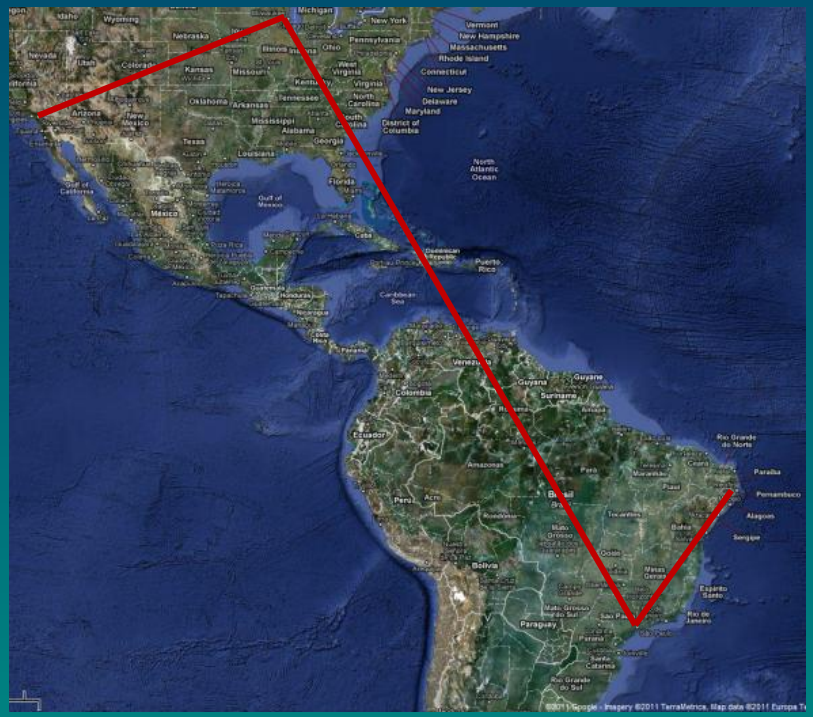

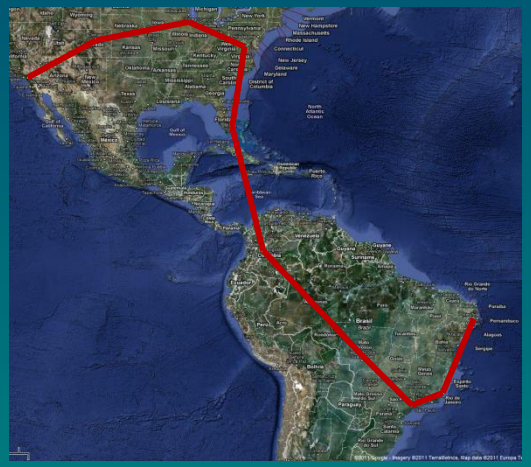

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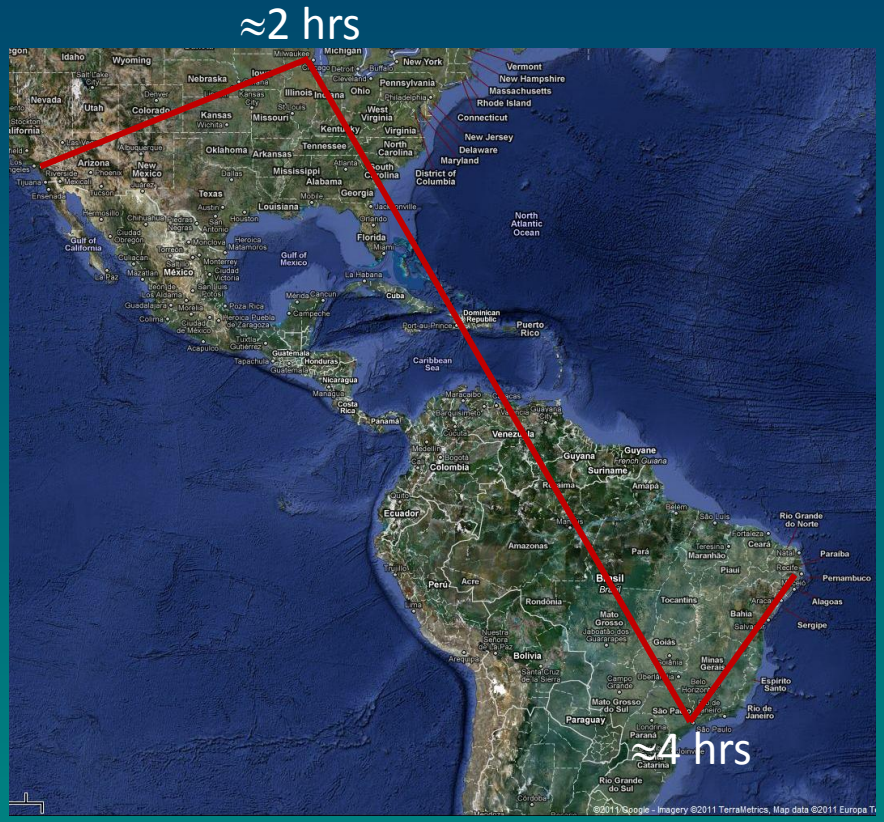
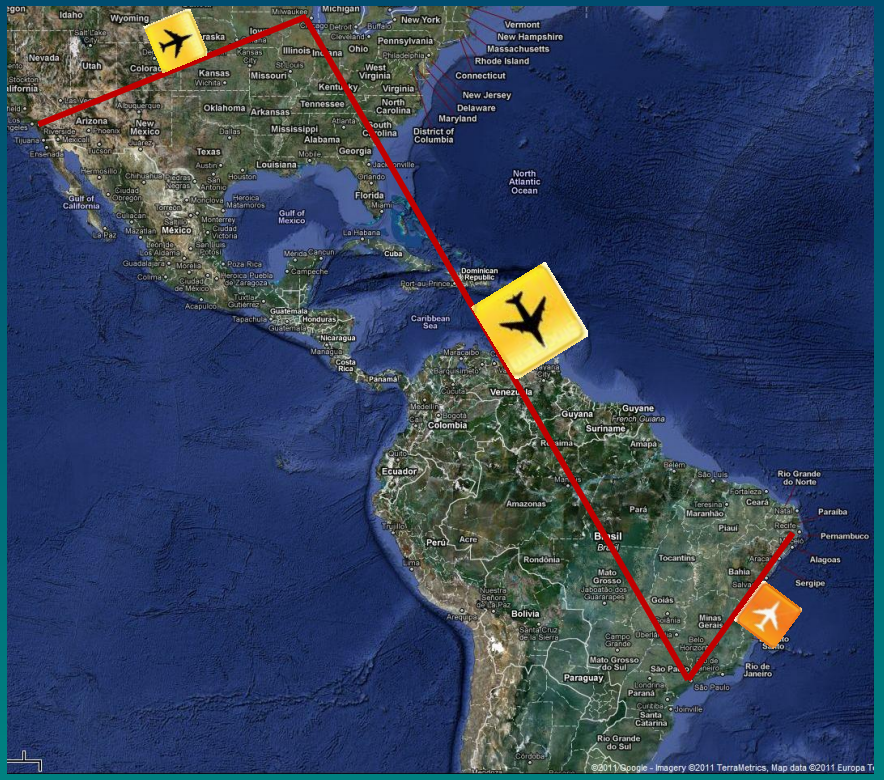
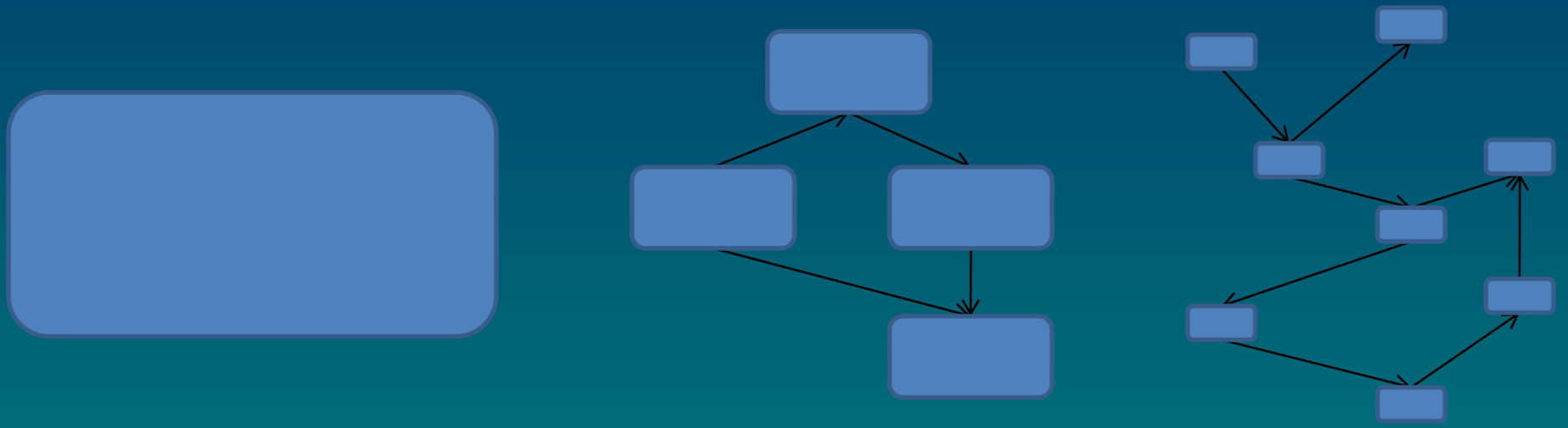




Modularity

- Modularity is a relative property of a system concerning how well its parts, and the relationships among the parts, support a certain purpose
- Modularity is a direct result of the specific modularization that is chosen
- Modularity can exist at multiple levels of abstraction, and be examined from multiple perspectives

Software



- Also must decide upon a modularization
- Also leads to modularity that can exist at multiple levels of abstraction and be examined from multiple perspectives

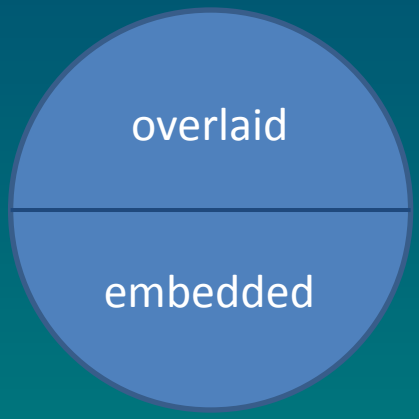
Purpose of Modularization

Level	Purpose
Individual developer	Reduce complexity of understanding and reasoning
Development team(s)	Enable parallel work
System's life cycle	Enable evolution
Multi-project	Support reuse
Organization	Configuration, customization, and creation of variants of the system

Large Body of Work

- Theory
  - objectives, guidelines, criteria, comparison of modularizations, …
- Programming languages and tools
  - object-orientation, interface definition languages, aspect-orientation, multi-dimensional separation of concerns, …
- Beyond programming languages
  - software architecture, product lines, multiple views, early aspects, traceability, …
- Non-modularization
  - conceptual modules, concern-based programming, …

A Concern-Based View of this Body of Work



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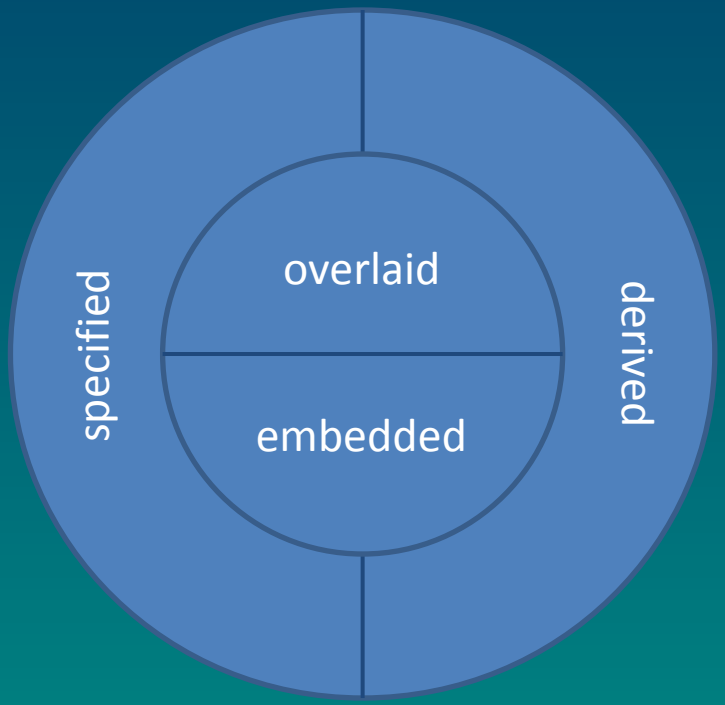

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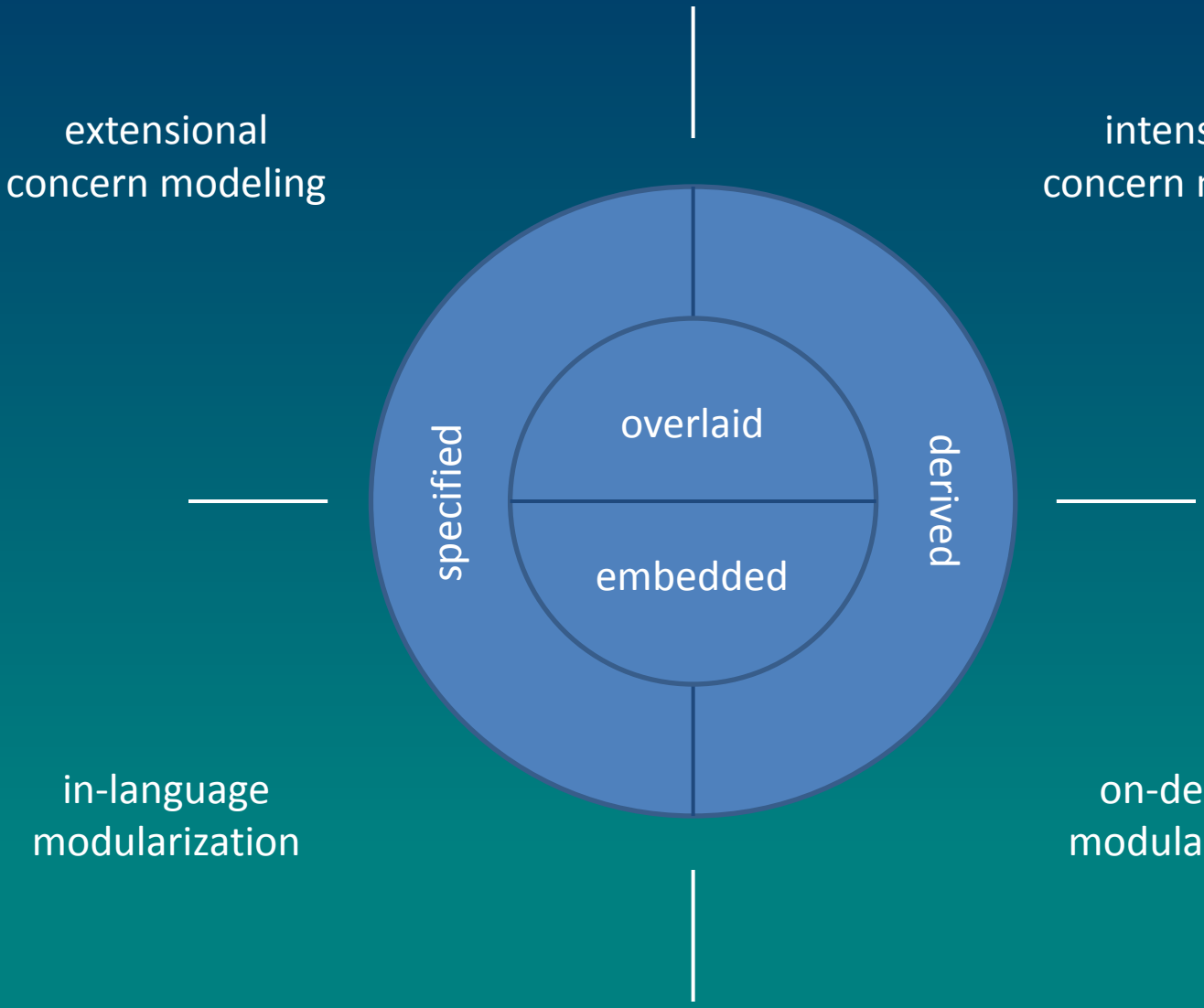

Modularity

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- Tools matter, perhaps especially but certainly not exclusively when modularity breaks down

Modularity: A Question

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How does one choose a specific modularization?

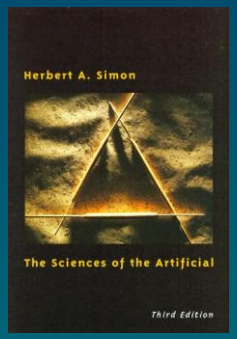
Modularity: An Answer

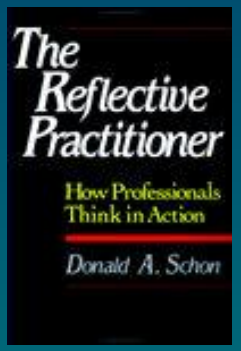
- The process of choosing a modularization is one of *design*

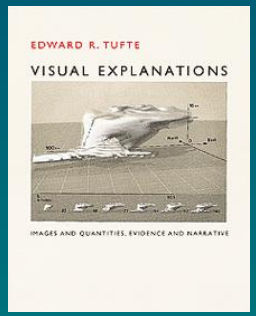
Modularity: An Answer

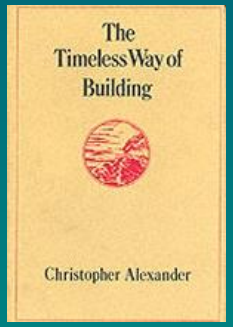
- The process of choosing a modularization is one of *design*
- What is design?

Design: An Interdisciplinary Perspective









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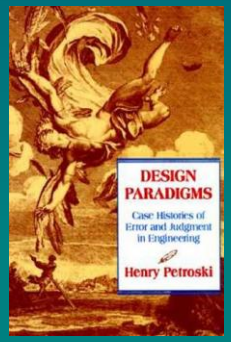
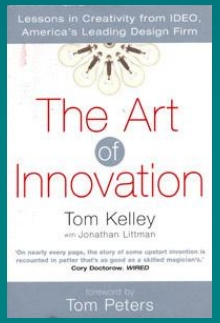
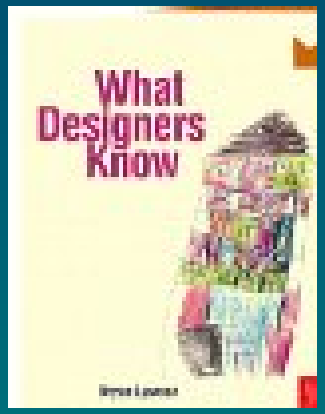
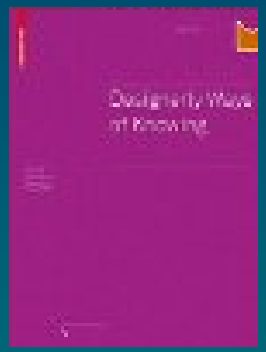
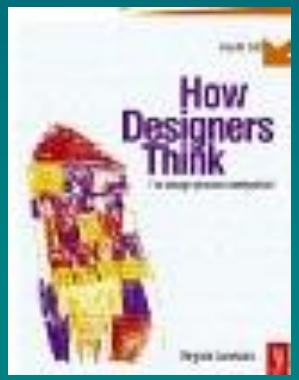


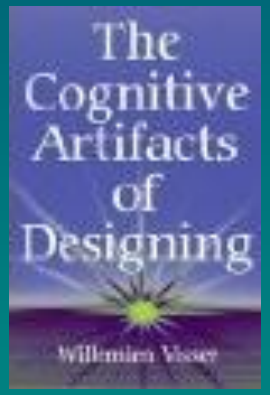


Design: An Interdisciplinary Perspective









… (and more)

Existing Definitions of Software Design

- Organization of a software system into modules / components / classes or other units
- After the purpose and specifications of software is determined, software developers will design or employ designers to develop a plan for a solution
- …

Existing Definitions of Design

- Decision making, in the face of uncertainty, with high penalties for error
- To choose the things we use shall look as they do
- A creative activity—it involves bringing into being something new and useful that has not existed previously
- Relating product with situation to give satisfaction
- The imaginative jump from present facts to future possibilities
- To form a plan or scheme of, to arrange or conceive in the mind, … for later execution

Existing Definitions of Design

- To initiate change in man-made things
- To plan or intend for a purpose
- To work out a solution in one's mind
- The transition from possible solutions to a specific one
- …

Three Themes

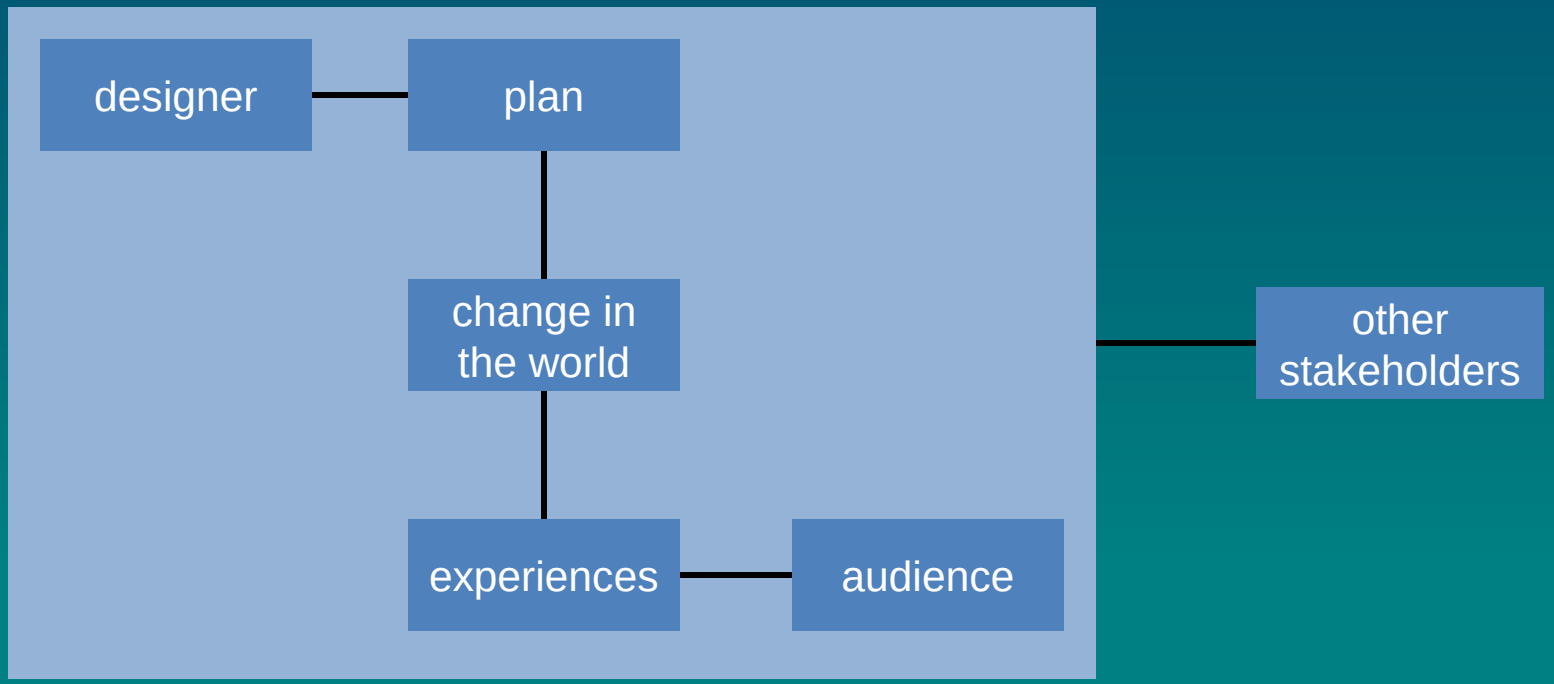
1. Design involves decision making to shape an envisioned future

2. The decisions together form a plan for actually enacting change in the world

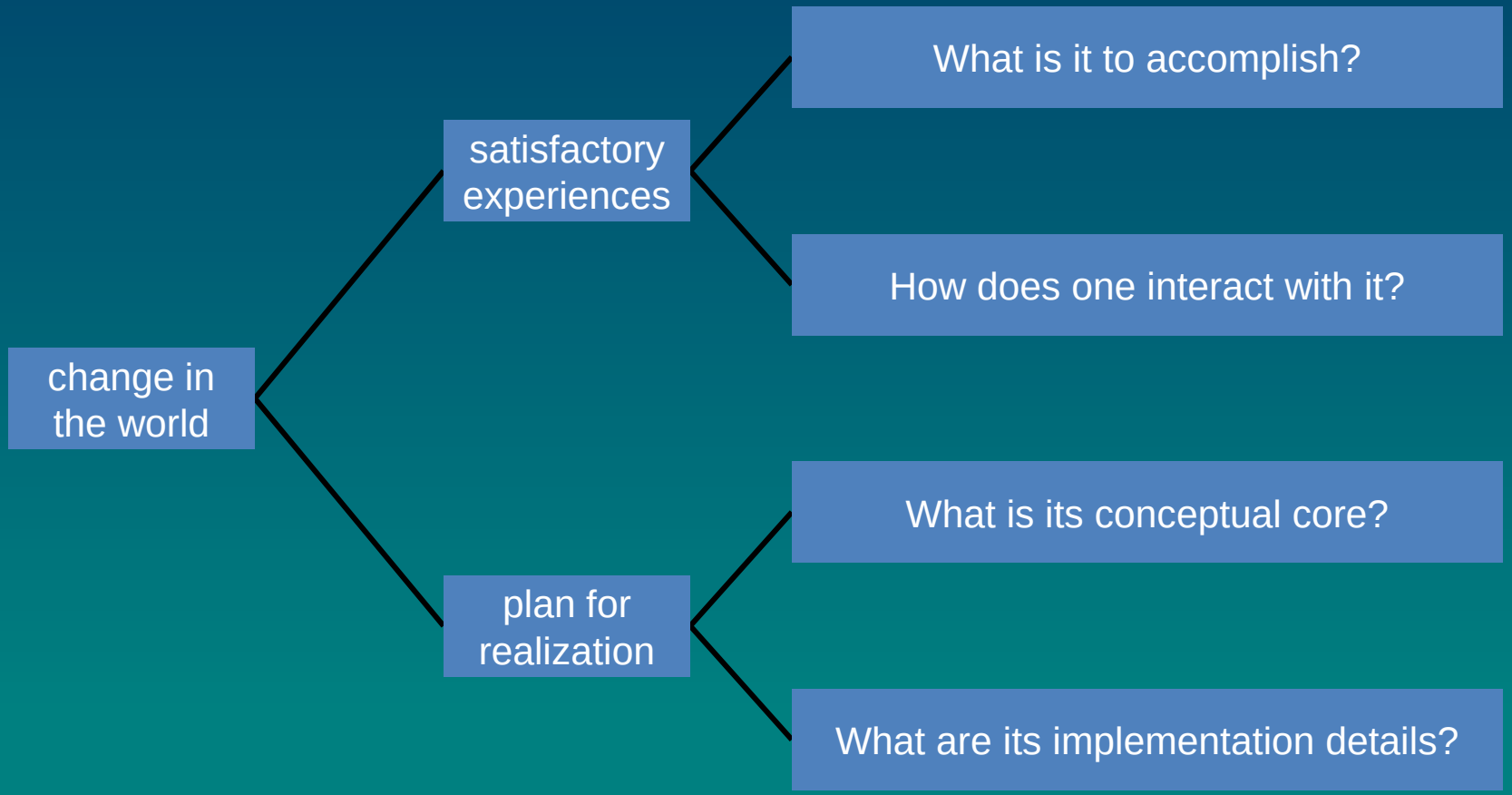
3. The change is consequential: stakeholders must be satisfied with the result

Our Definition of Design

- To decide upon a plan for change in the world that, when realized, satisfies stakeholders



Key Questions to Answer



Restated In Software Design Terms

Type of design	Key question to answer
Application design	What is the change in the world to accomplish?
Interaction design	How does one interact with the change in the world?
Architecture design	What is the conceptual core of the change in the world?
Implementation design	What are the implementation details of the change in the world?

Software Design in a General Design Perspective

- Seen through this lens of general design, software design takes place across the entire life cycle
- Seen through this lens of general design, the code as shipped is the final software design
- Seen through this lens of general design, the various life cycle approaches are merely high-level design processes

Who Are the Designers?

- Software architects
- User interface/interaction designers
- Database designers

- Business architects
- Requirements engineers
- Programmers
- Testers

- Clients

- …

The study of modularity, and its role in design, should take all of these roles into account

What Do They Produce?

- Diagrams
- Sketches

- Mindmaps
- Documents
- Presentations

- Second-life prototypes

- Code

- …

The study of modularity, and its role in design, should take all of these artifacts into account

How Do They Produce It?

- Knowledge application
  - apply patterns or style, reuse past solutions, rules of thumb, …
- Pure idea generation
  - brainstorm, doodle, talk, mindmap, …
- Research via approximations
  - prototype, storyboard, sketch, …
- Communication
  - interview stakeholders, call experts, talk to colleagues, learn technology, …

The study of modularity, and its role in design, should take all of these activities into account

Modularity: A Research Agenda

- Where lie the benefits of modularity in each of the design activities?
- What forms of modularity enable the benefits?
- What is the cost of achieving modularity?
- Where do our current modularization techniques fall short in supporting the activities of software designers?
- How can we improve the current state of the art in modularity?

The Paper: Seven Vignettes

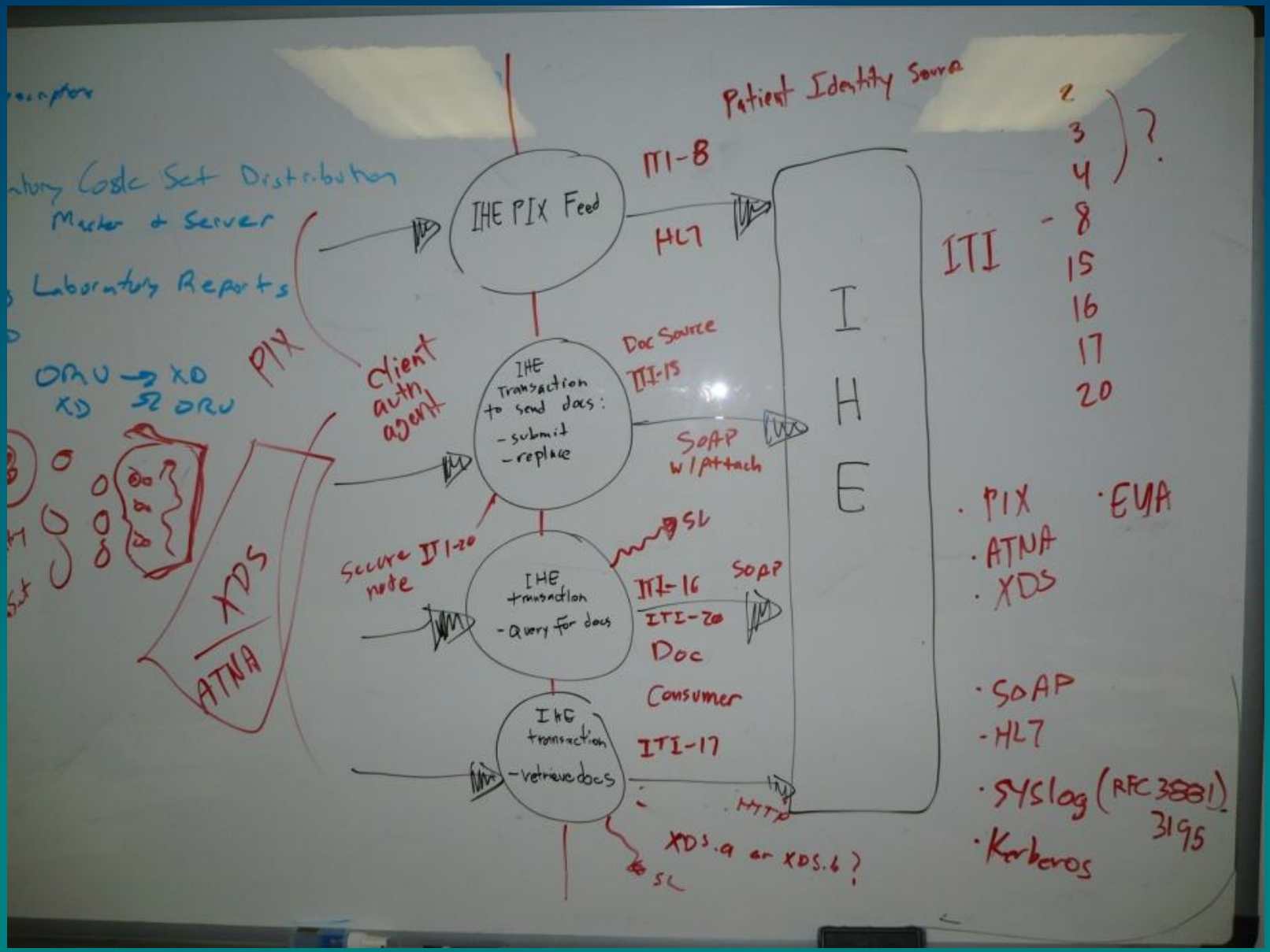
- Sketching
- Refinement
- Provisionality
- Design progression (1)
- Design progression (2)
- Distributed development (1)
- Distributed development (2)

This Talk: Four Vignettes (Bonus Demo, If Network…)

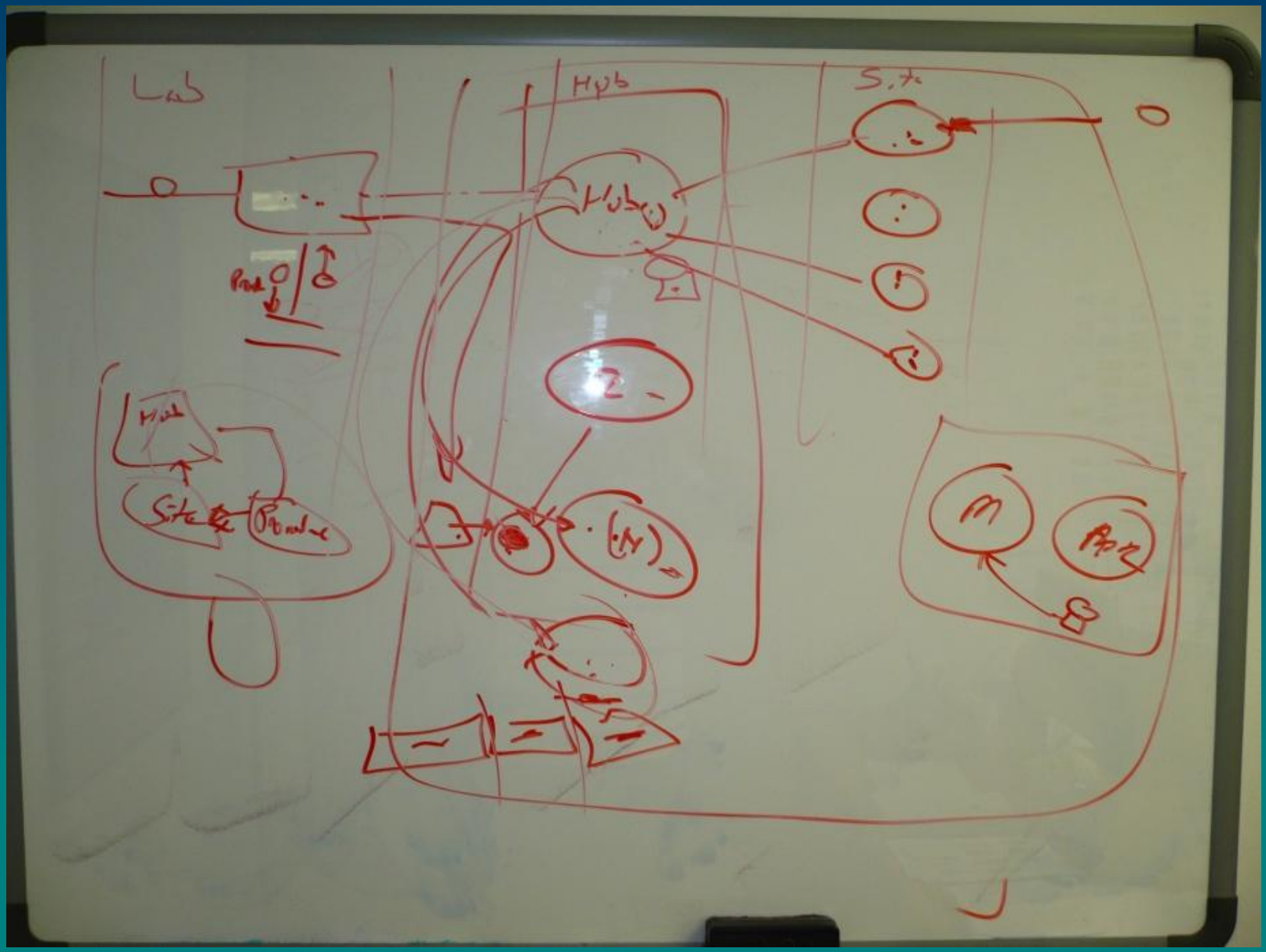
- Sketching
- Refinement
- Provisionality
- Design progression (1)
- Design progression (2)
- Distributed development (1)
- Distributed development (2)

- First three are partially rooted in results and observations from SPSD 2010 – Studying Professional Software Design

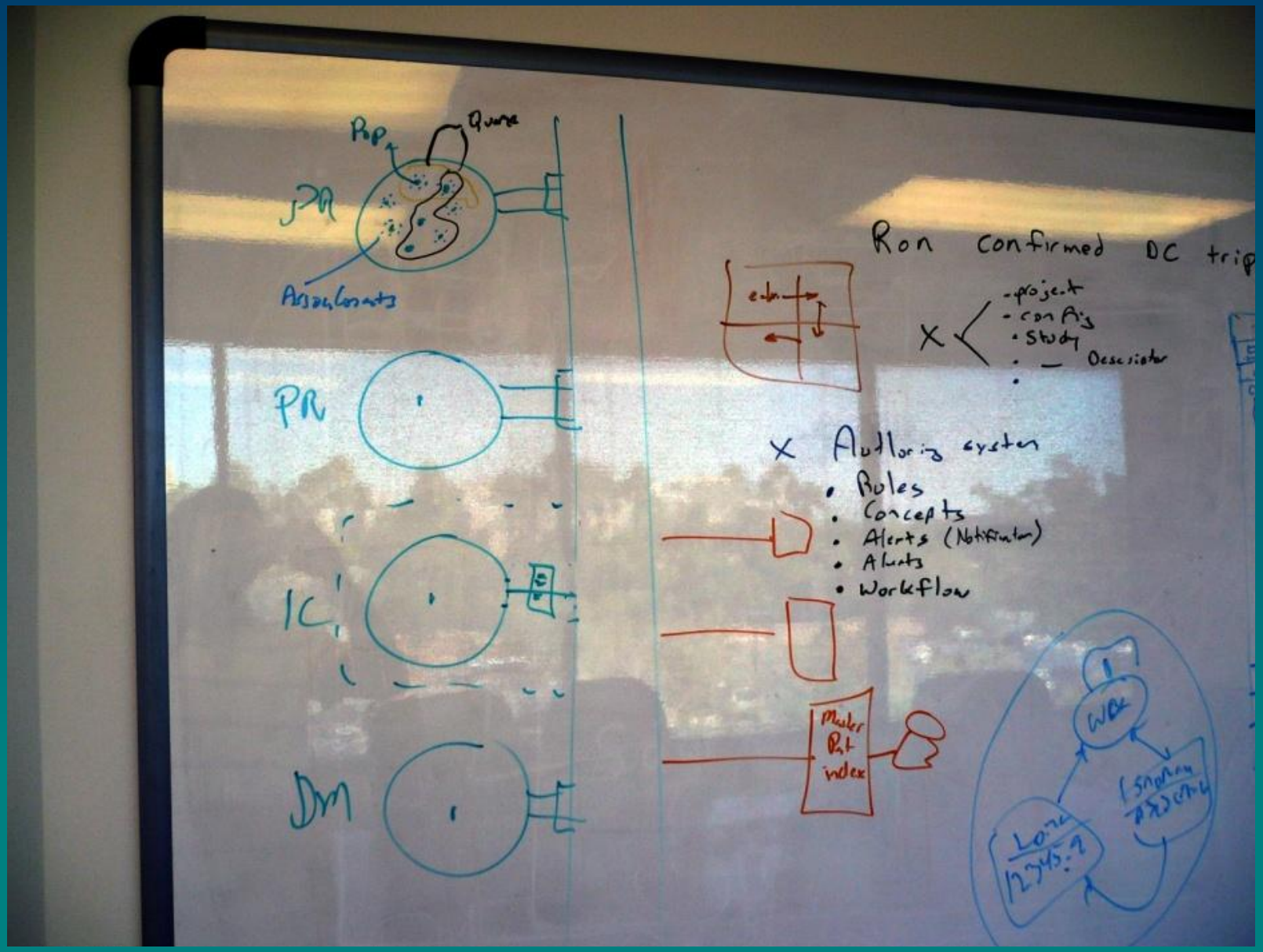
Sketching


Patient Identity Sour
IHE PIX Feed
ITI-8
HL7
ITI
I H E
Doc Source
ITI-15
SOAP w/Attach
IHE Transaction to send docs: - submit - replace
PIX
Client auth agent
XDS
ATNA
Secure
ITI-16
ITI-20
SOAP
IHE transaction - query for docs
Doc Consumer
ITI-17
IHE transaction - retrieve docs
HTTP
XDS.a or XDS.b ?
SL
Laboratory Reports
ORU → XD
XD → ORU
· PIX
· ATNA
· XDS
· EUA
· SOAP
· HL7
· Syslog (RFC 3881)
· Kerberos
3195

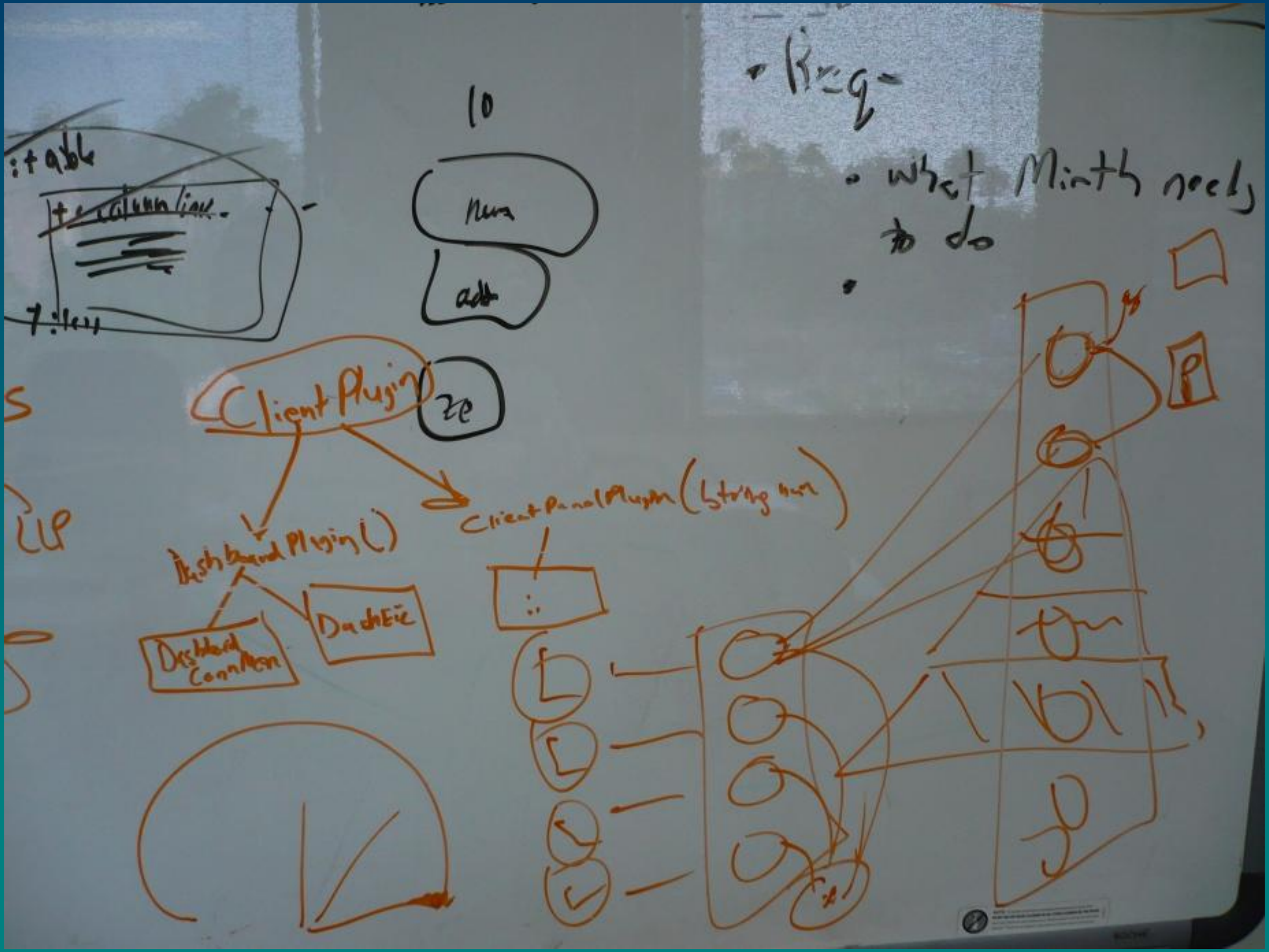
Sketching



Sketching


Ron confirmed DC trip
PR
IC
DM
Authoring system
Rules
Concepts
Alerts (Notification)
Alerts
Workflow

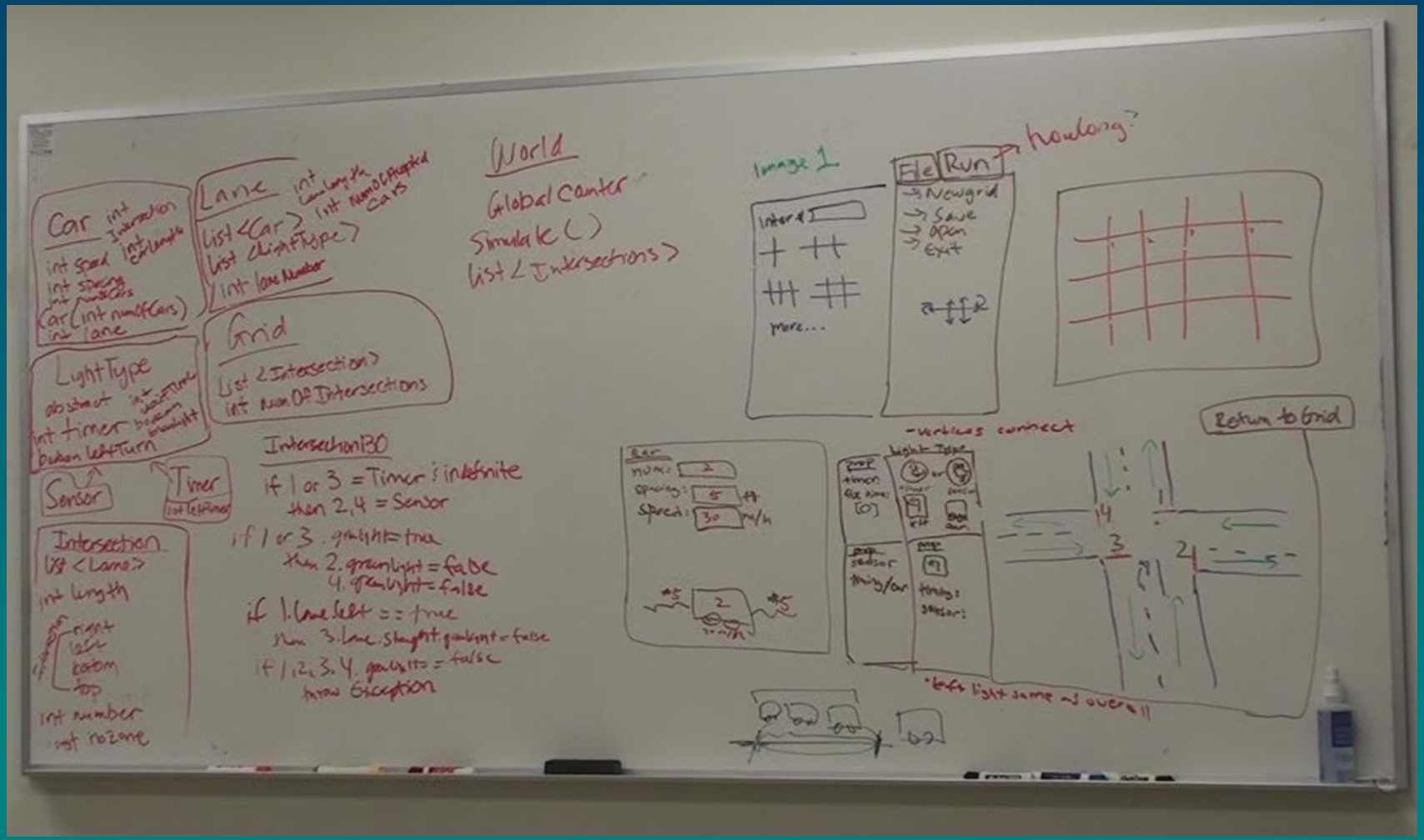
Sketching



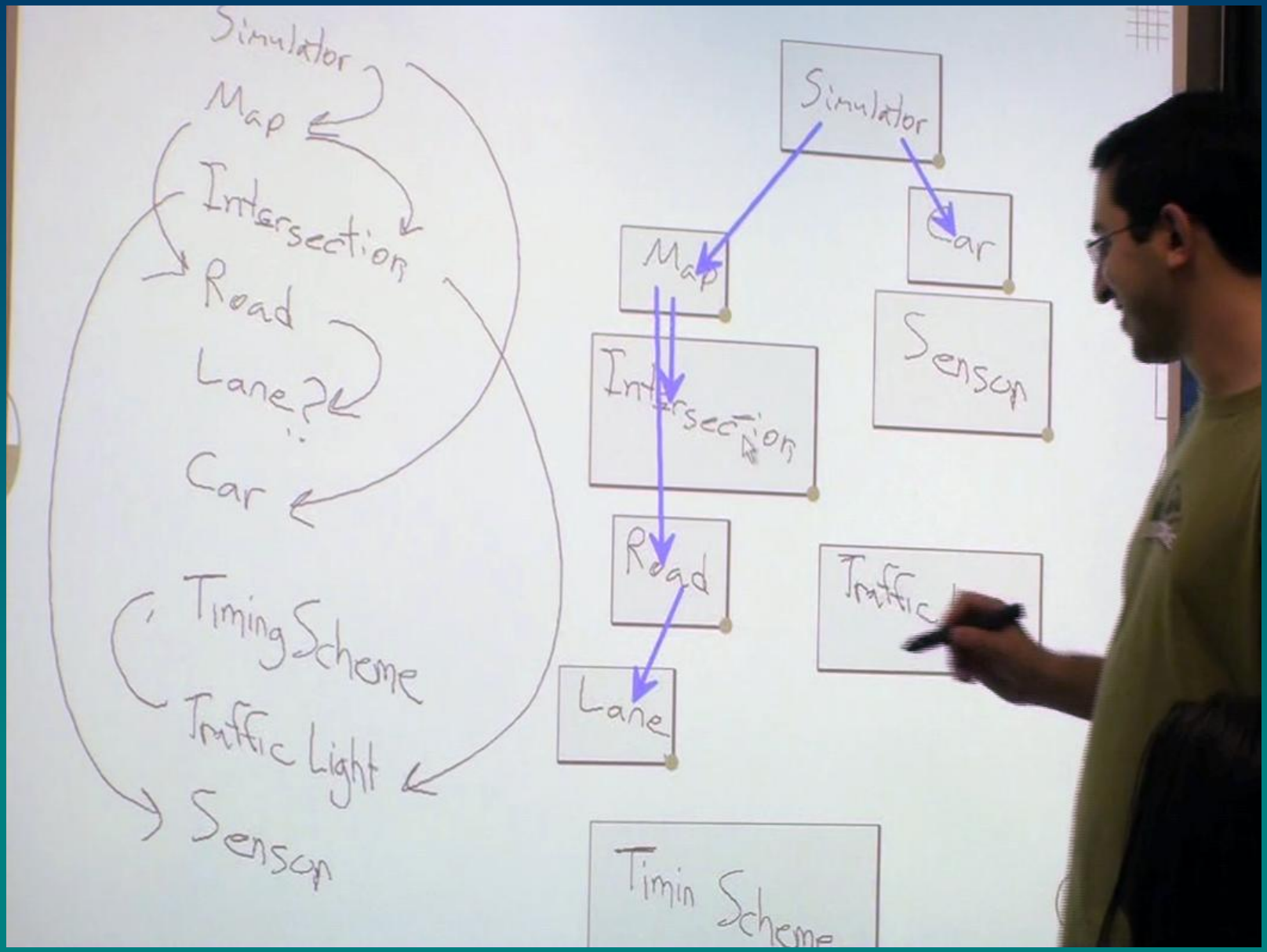
Sketching: Research Questions

- What are the parts and relationships in sketching?
- From a modularity point of view, what purposes do these parts and relationships support?
  - understand and reason
  - parallel work
  - reuse
  - evolve
- What, if anything, can we learn from the impromptu notations that software designers use?
- Can we build tools that actively support software design sketching?

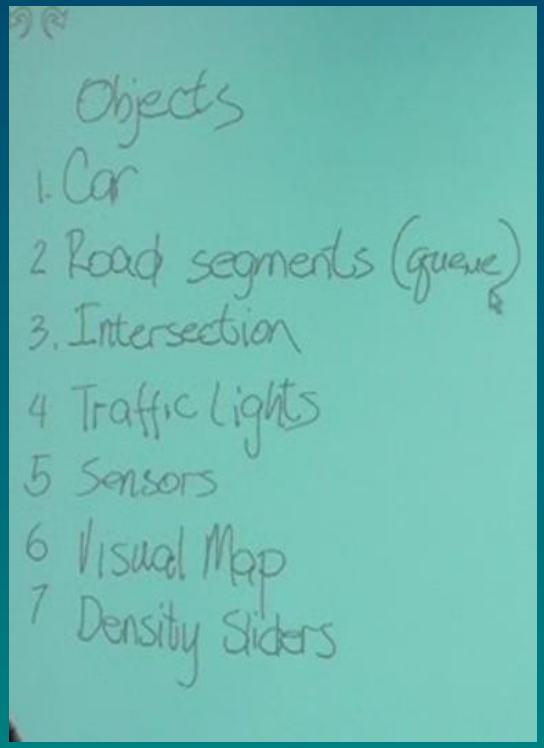
Refinement

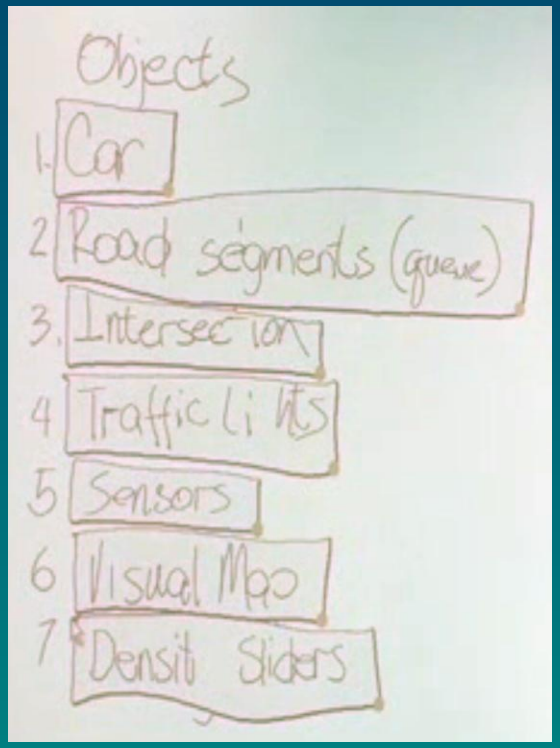

Car
Lane
World
Grid
LightType
Sensor
Timer
Intersection
Global center
Simulate()
Image 1
File
Run
Newgrid
Save
Open
Exit
more...
Return to Grid

Refinement


Simulator
Map
Intersection
Road
Lane
Car
Timing Scheme
Traffic Light
Sensor
Simulator
Map
Car
Sensor
Intersection
Road
Lane
Timin Scheme

Refinement


Objects
1. Car
2 Road segments (queue)
3. Intersection
4 Traffic Lights
5 Sensors
6 Visual Map
7 Density Sliders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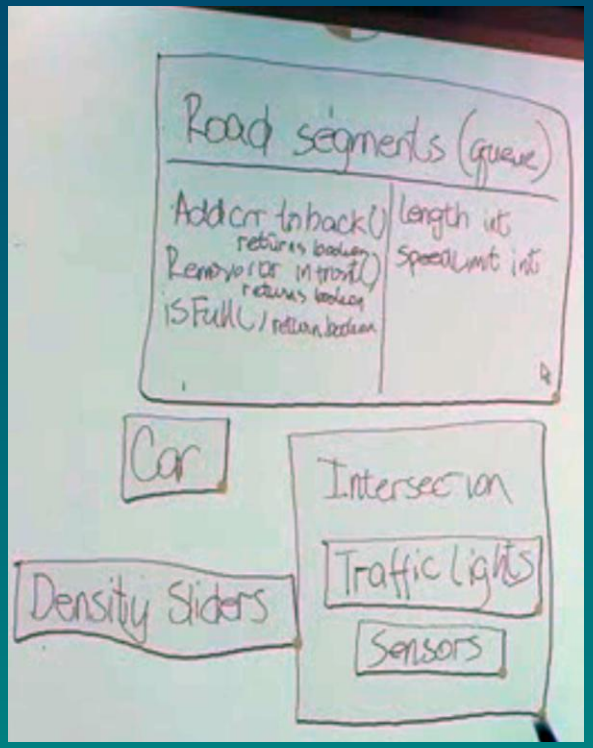
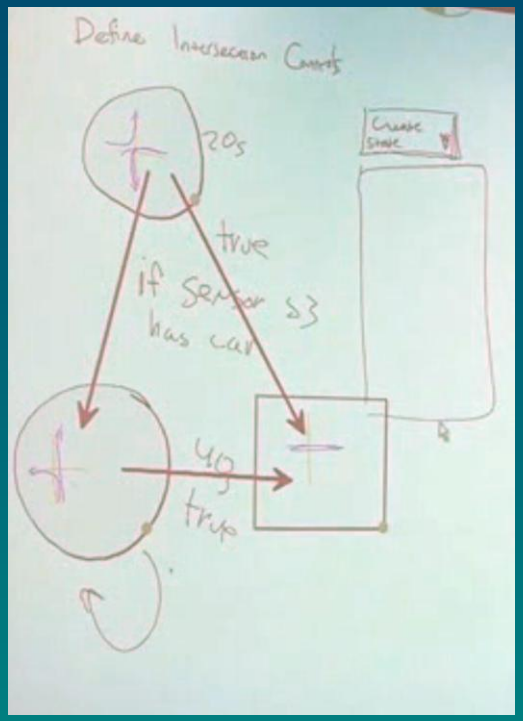
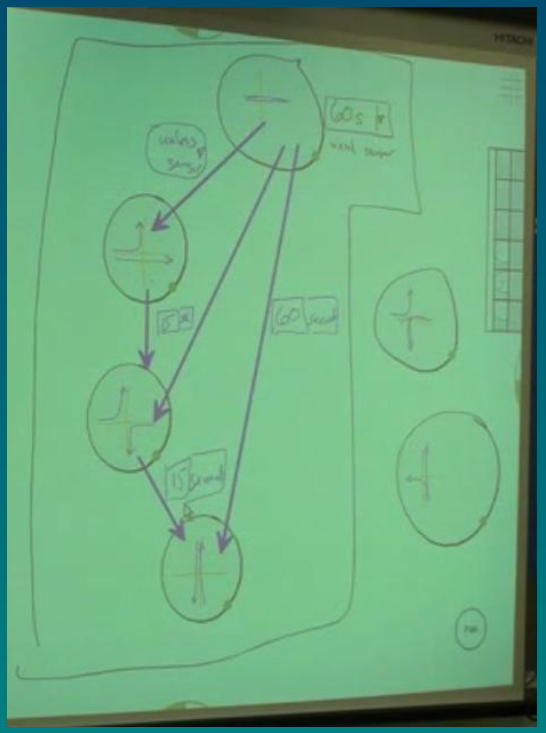
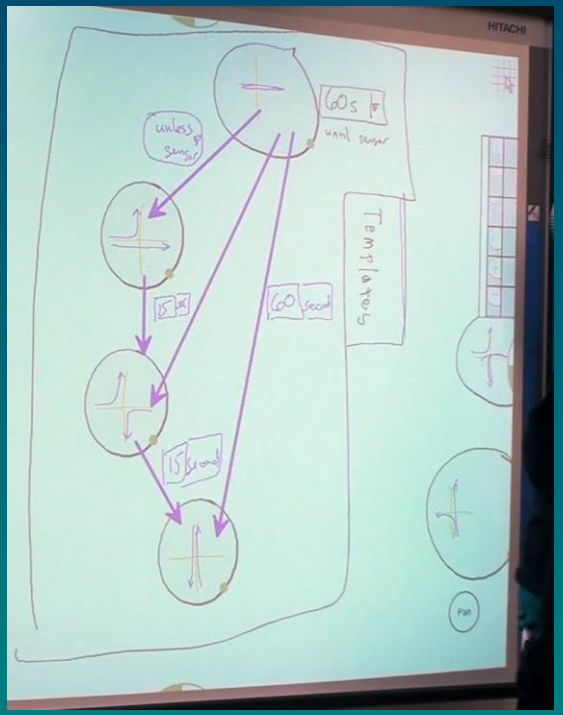

Road segments (queue)
Add car to back()
returns boolean
Remove car in front()
returns boolean
IsFull()
Length ints
Speed limit ints
Car
Intersection
Traffic Lights
Sensors
Density Sliders

Refinement


Define Intersection Events
20s
true
if Sensor S3
has car
40
trip


60s
unless
sensor
60 seconds
15 seconds


60s
unless
sensor
Templates
60 seconds
15 seconds

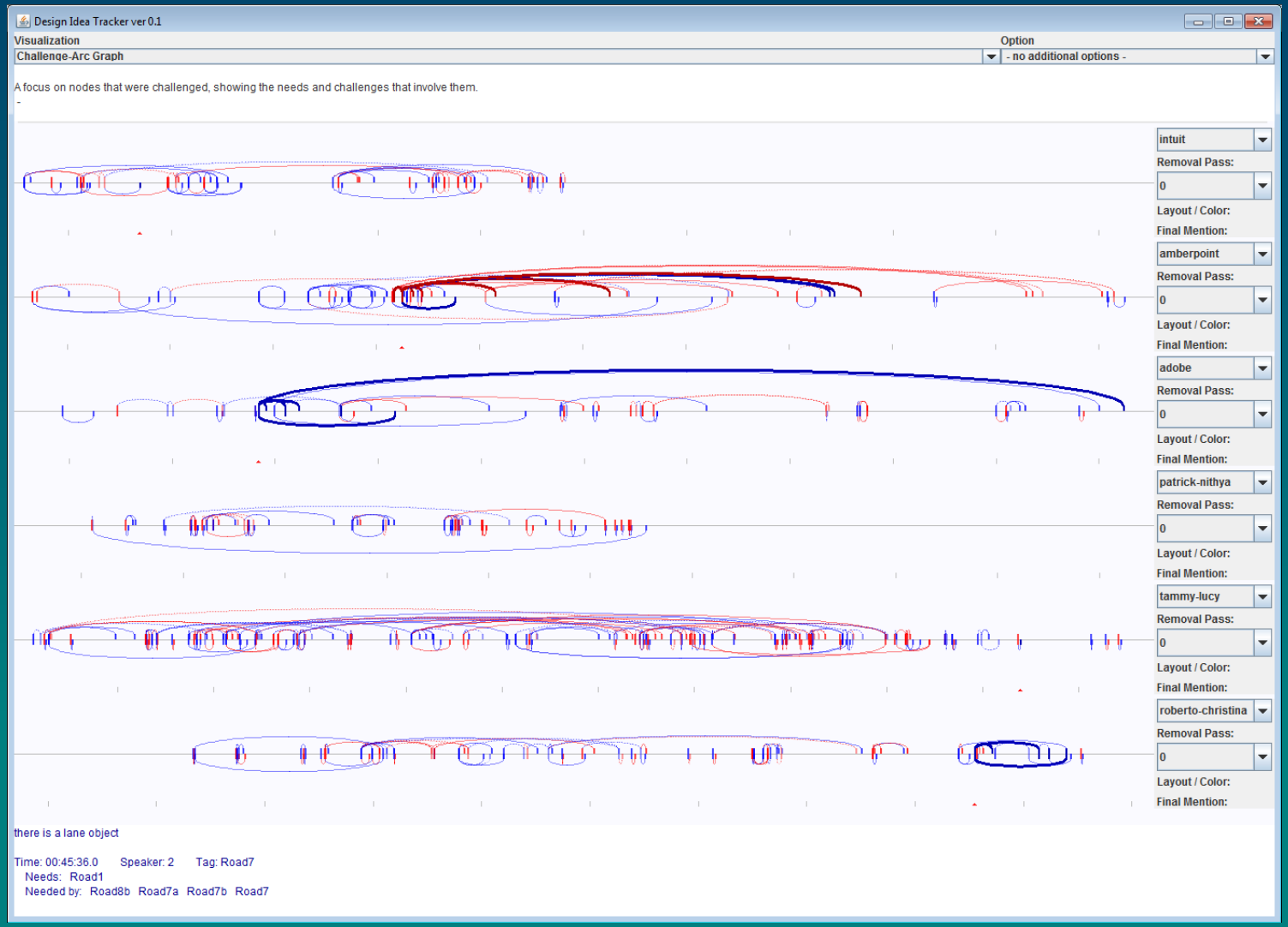
Refinement: Research Questions

- How do the parts and relationships evolve in sketching?
- From a modularity point of view, does the purpose shift as well?
- To what degree may typing play a role?
- Do designers “un-refine”?
- From code to sketch?

Design Progression (1)

- (video clip from Studying Professional Software Design 2010)

Design Progression (1)



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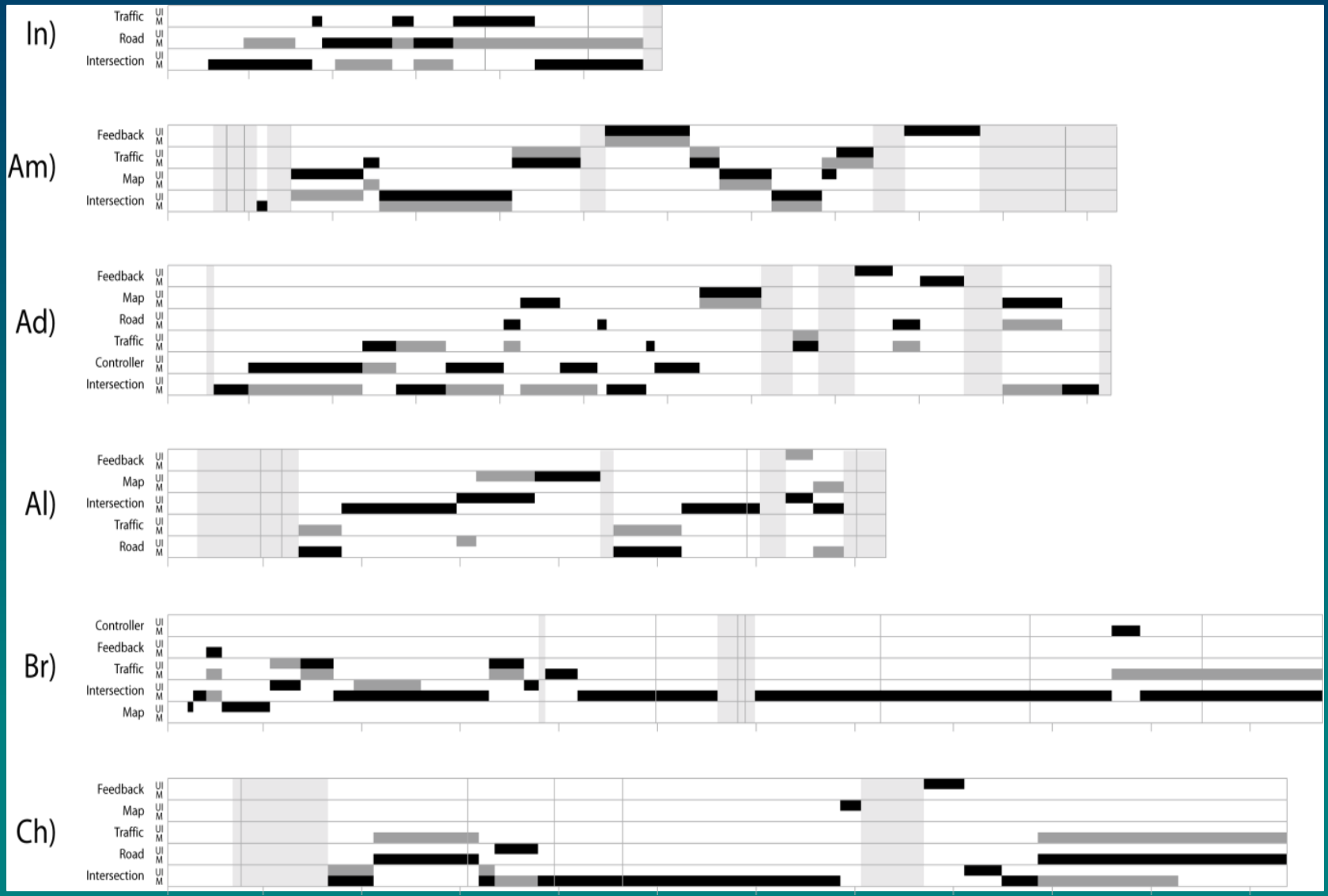
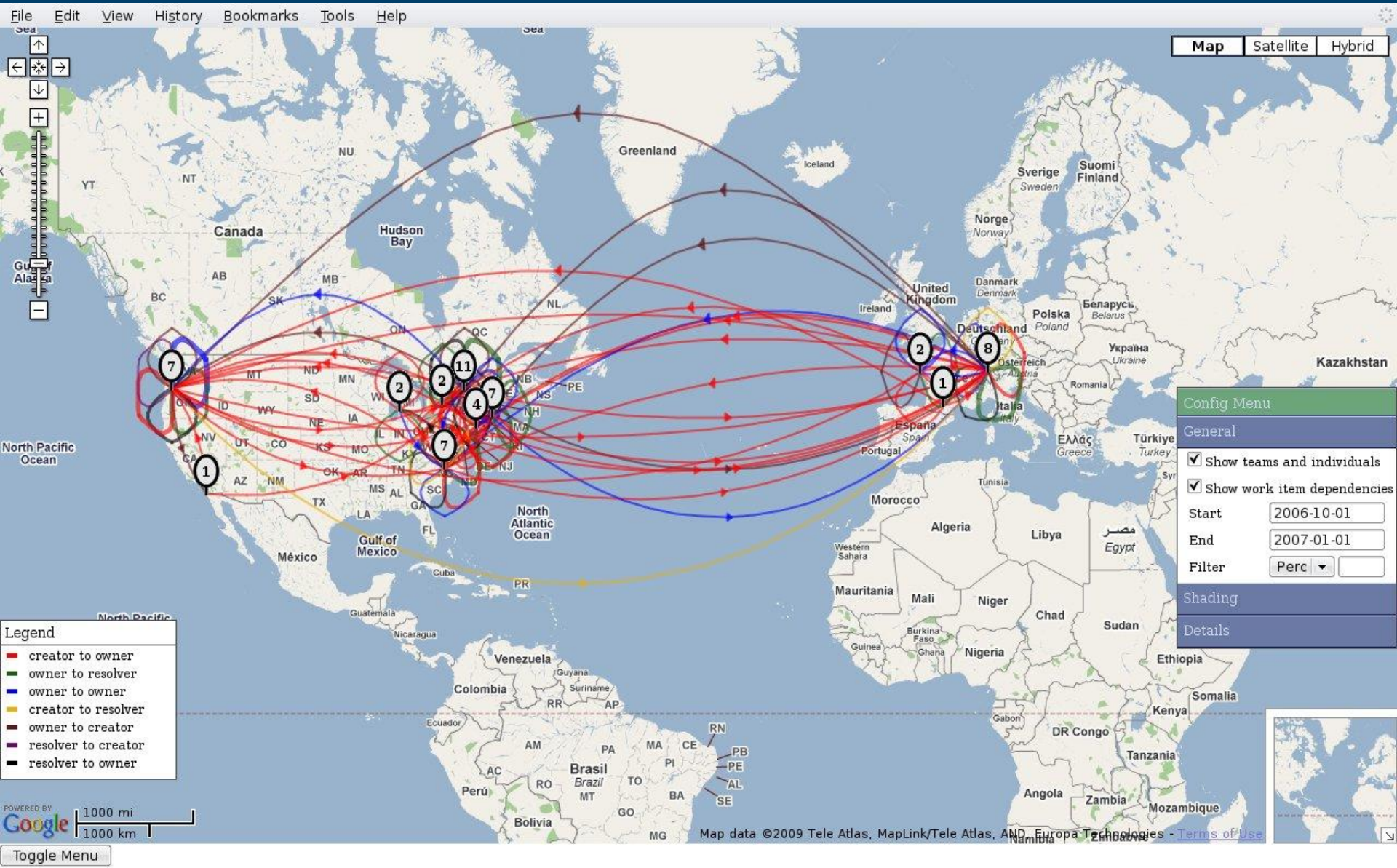


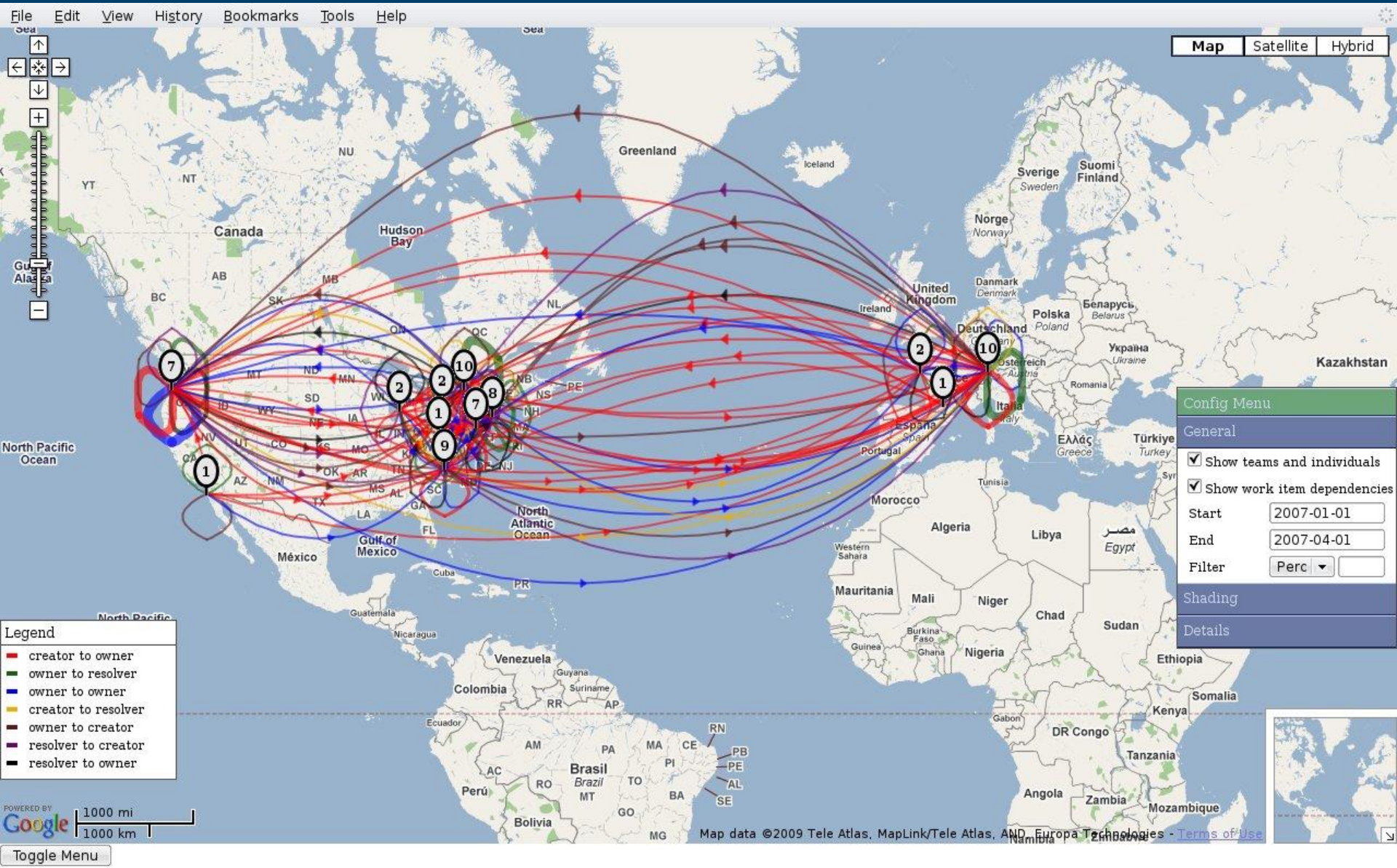
Design Progression (1): Research Questions

- What is the nature of these subjects?
- Can tools leverage or otherwise encourage pair-wise rotation?
- Do any other such imperceptive patterns of design activity exist?
- The expert versus novice question…

Distributed Development (2)



Distributed Development (2)



Distributed Development (2)

Distributed Development (2)

- (videos of Scarab)

Distributed Development (2): Research Questions

- What is the role of APIs in these scenarios?
- Could re-modularizing reduce these problems?
- Should we be designing more for coordination, and less for understanding?
  - or may awareness and other coordination tools overcome the problem?

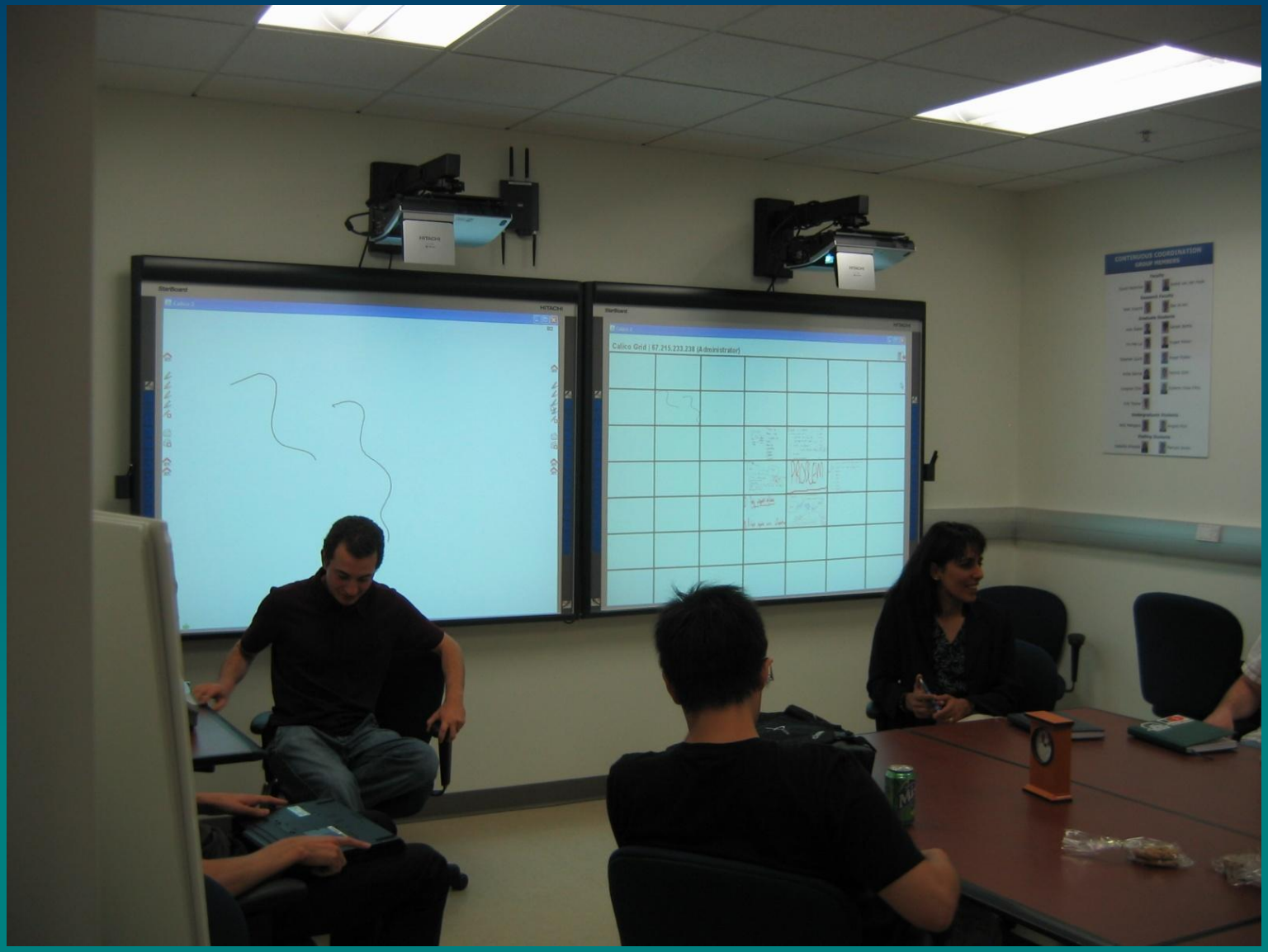
Discussion

- Our vignettes represent merely a slice of the broad range of activities, notations, and designers we encounter in real life
- Some general observations
  - modularization is typically *not* the main goal of design, and often not even a topic of explicit conversation until late
  - interplay between problem understanding and solution building
  - immediate versus emerging modularizations
  - expressiveness versus usability
  - once more, tools
  - design is social
- Caveat: quality of the designs

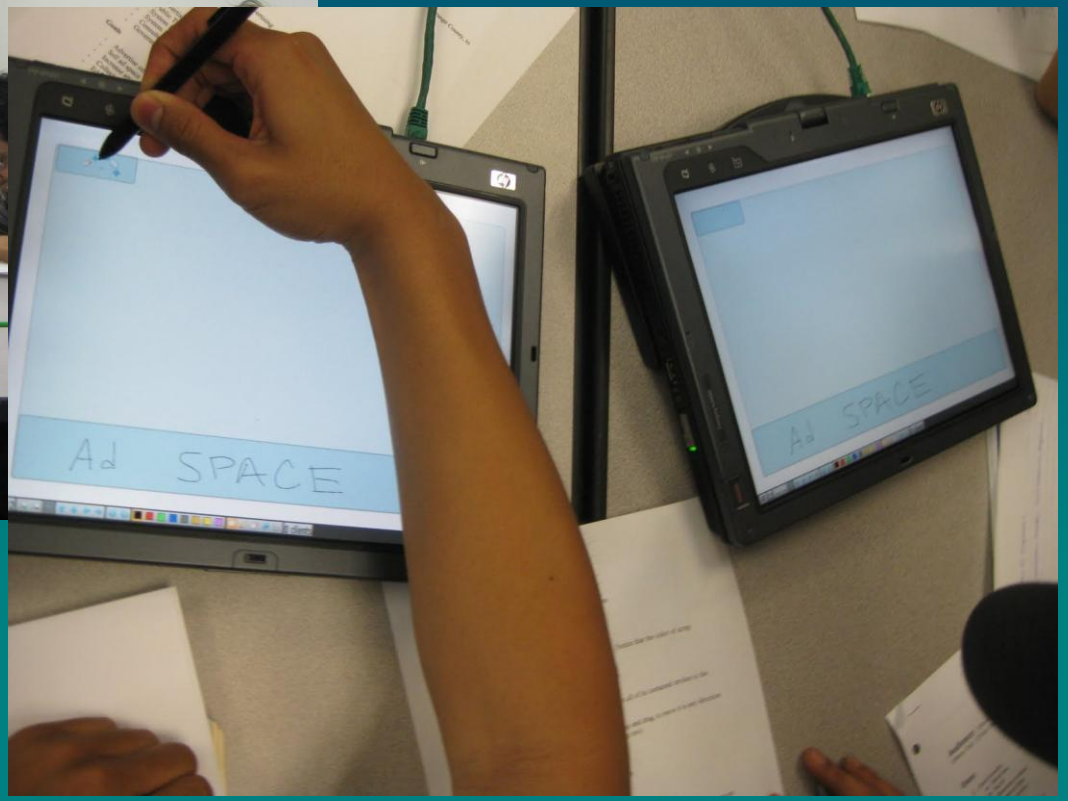
Road Forward

- Additional studies
- “Bringing designers to tools” or “Bringing tools to designers”?
- What is the purpose?
- Classroom

Sketching: Calico Demo



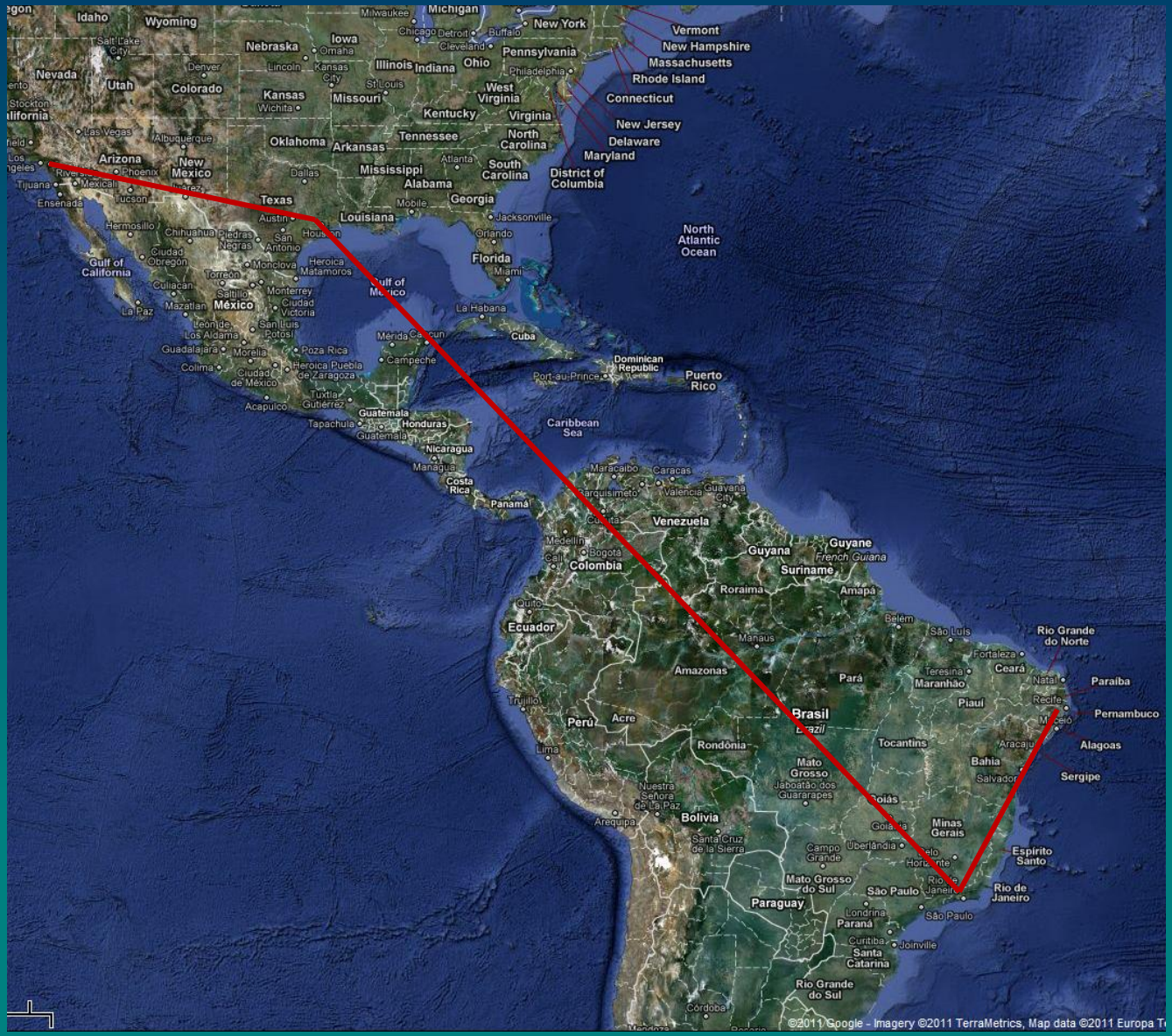
Classroom



Conclusion

- Treat software engineering as a design discipline
  - study it as such
  - provide the tool support as such
  - teach it as such
- Modularity is in the eye of the beholder
  - not a single, absolute property of the code

And Finally…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Georgia
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Arizona
New Mexico
California
North Atlantic Ocean
Gulf of California
Gulf of Mexico
Caribbean Sea
Cuba
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Thank You

Realities

- Building an understanding of a design problem goes hand-in-hand with building an understanding of its design solution, and vice versa
  - this understanding may well change, sometimes radically so
- A design's success is not absolute, but judged relative to other possible designs that could have been made
  - a designer must make tradeoffs all the time
- A change in the world may last for a very long time
  - accommodate future changes in the world
- There is no optimal solution to a design problem, designers must find a solution that is good enough

Characteristics of Design

- Design is creative
- Design is decision making
- Design is uncertain
- Design is constrained
- Design progresses non-linearly

Brooks?!

- Invisibility
- Conformity
- Changeability
- …?

Routine, Adaptive, and Original Design