

# Introduction to CS585

CS585 Software Verification and Validation

<http://cs585.yusun.io>

January 5, 2014

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<http://yusun.io>

[yusun@cpp.edu](mailto:yusun@cpp.edu)



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CAL POLY POMONA

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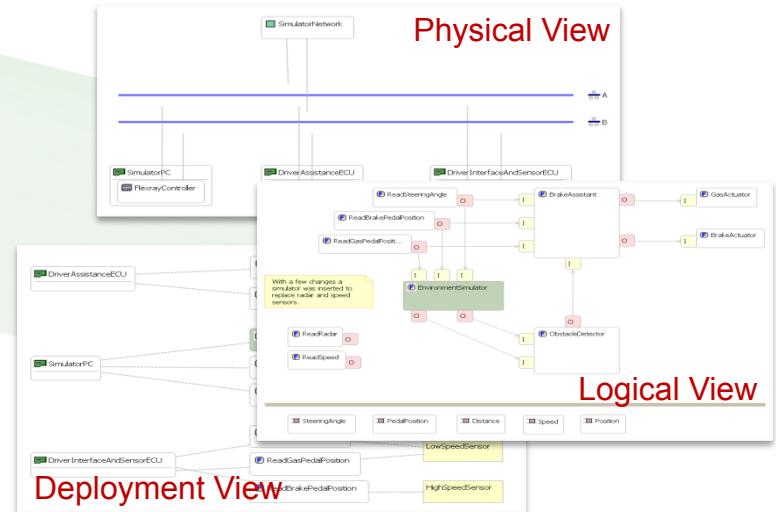
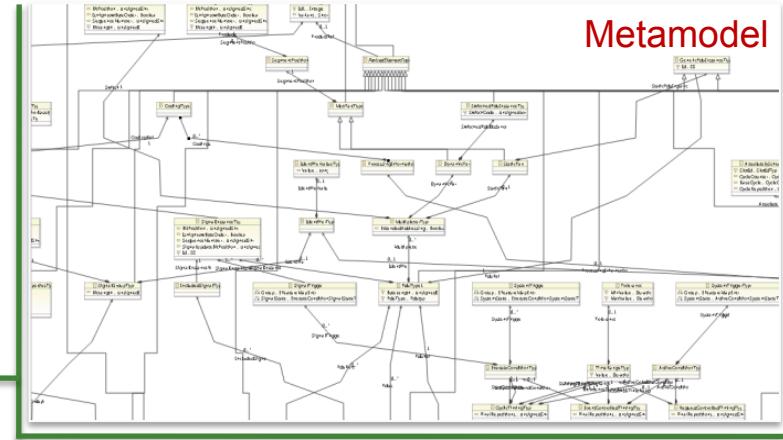
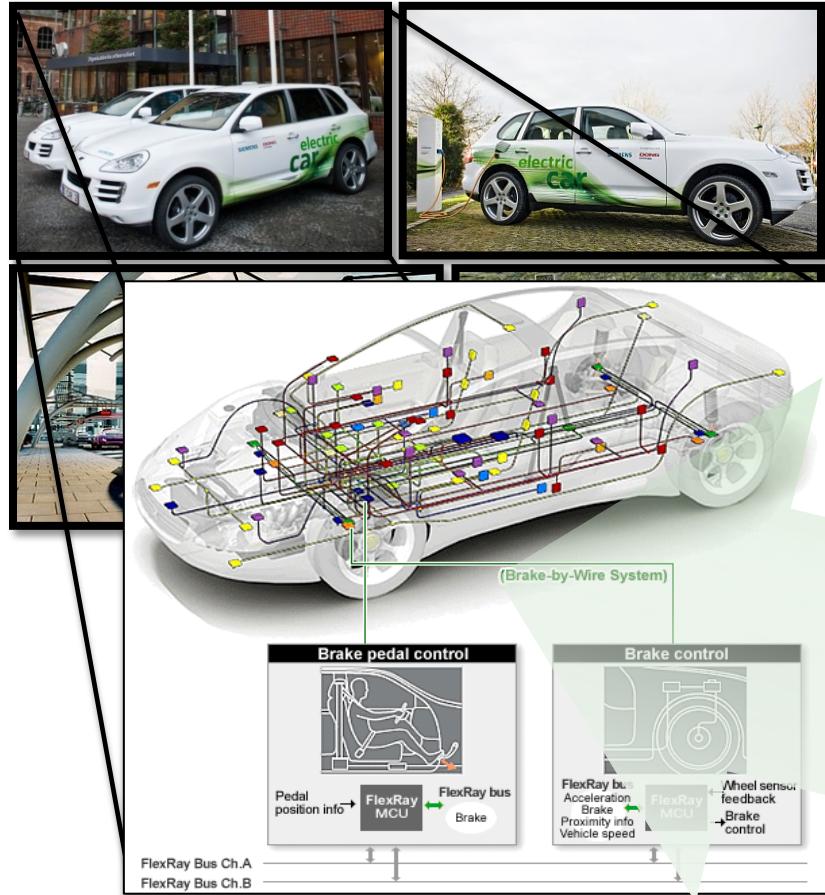
# About Myself

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# Embedded Software Systems

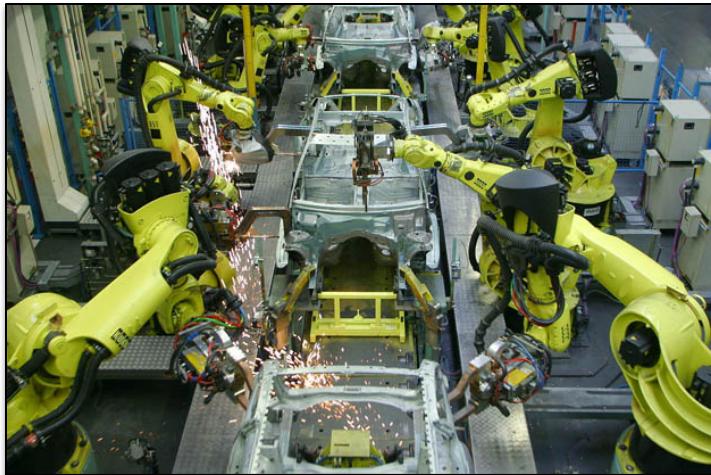
SIEMENS



# Embedded Software Systems

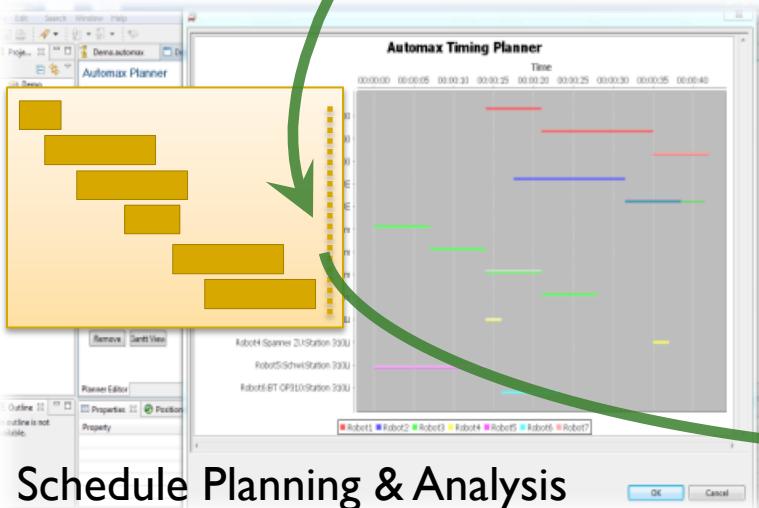


Mercedes-Benz

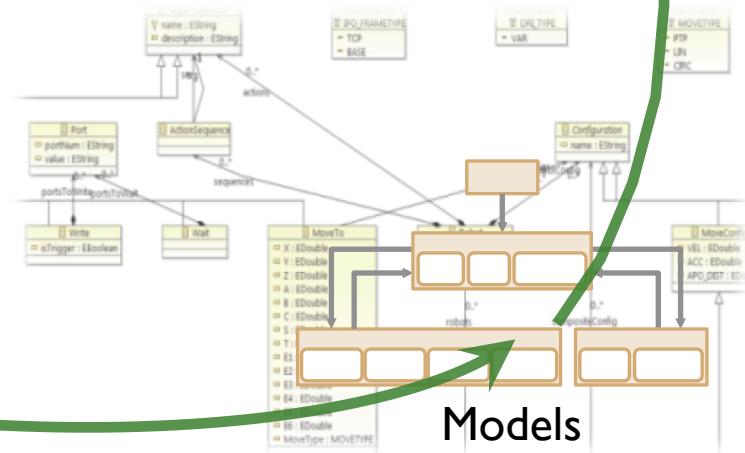


```
;FOLD PTP LHM110 CONT Vel= 100 % PDA133 Tool[9]:GR01_HC_M Base[0];%(FE)%R 5.2.34,%MKUKATPBASIS,%MOVE,VPTP,%P 1:PTP, 2:LHM110
;SWDOSTART = FALSE
;PDAJ_ACT=PDA133
;PDAJ_ACT=LHM110
;BAS (#PTP_PARAMS,100)
;PTP VPTP
;ENDFOLD
;:FOLD : Bauteil Entnommen ST300:(PE)
;ENDFOLD
;:FOLD SYN OUT 3250 "A32501--IRM Bau
;TRIGGER WHEN DISTANCE>0 DELAY>0 DO
;ENDFOLD
;:FOLD : Ausser Bereich ST300:(PE)
;ENDFOLD
;:FOLD SYN OUT 3281 "A32811--Ausser
;TRIGGER WHEN DISTANCE>0 DELAY>0 DO
;ENDFOLD
;:FOLD PTP LHM120 CONT Vel= 100 % P
;SWDOSTART = FALSE
;PDAJ_ACT=PDA132
;PDAJ_ACT=LHM120
;BAS (#PTP_PARAMS,100)
;PTP XLMH120_C_PTP
;ENDFOLD
;:FOLD PTP LHM130 CONT Vel= 100 % P
;SWDOSTART = FALSE
;PDAJ_ACT=PDA124
;PDAJ_ACT=LHM130
;BAS (#PTP_PARAMS,100)
;PTP XLMH130_C_PTP
;ENDFOLD
```

Control Code



Schedule Planning & Analysis



Models

# Amazon Silk



- Amazon Silk
- Cloud-Based Web Browser  
for Amazon Kindle Devices



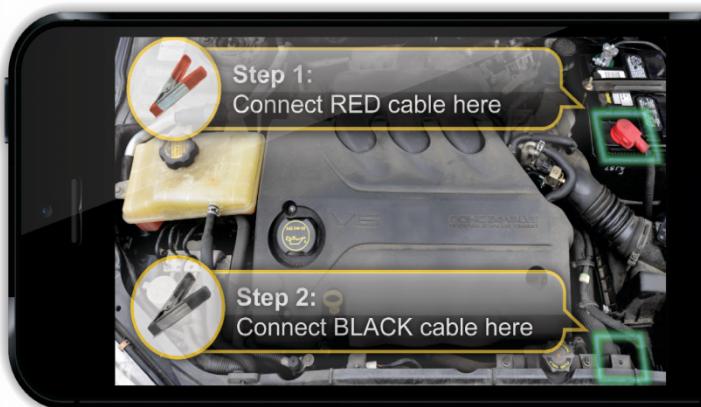
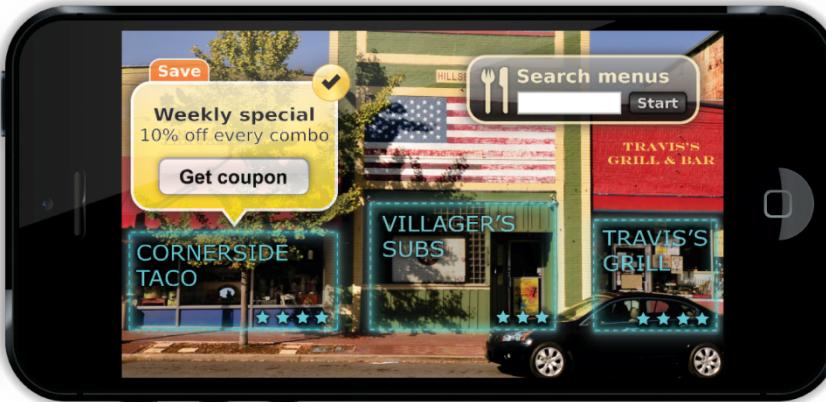
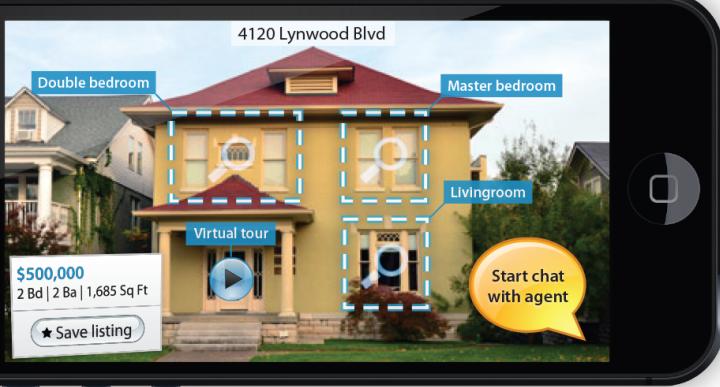
# Cloud-based Mobile Software Systems



# Mobile Augmented Reality

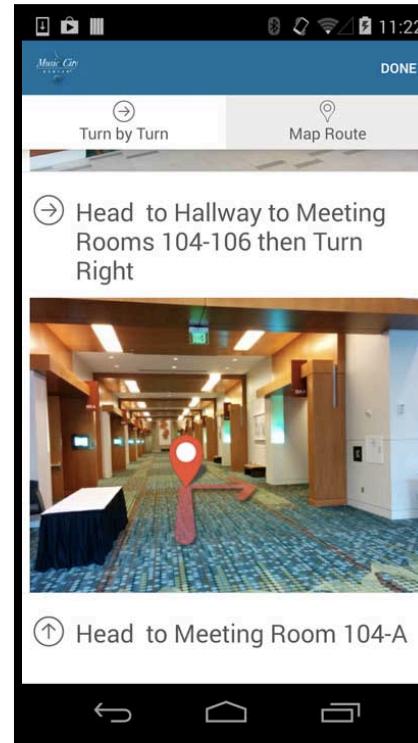
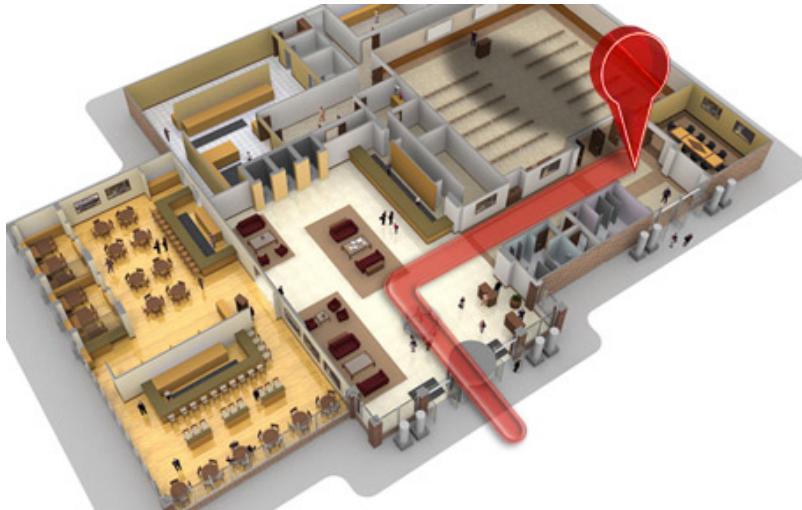


# Mobile Augmented Reality



For more info and demos: <http://www.cloudpoint.io/>

# Ziiio – Indoor Navigation System



- Indoor Navigation System
- <http://zii.io>

# iVote – Web-Based iClicker



**The Class of CS140**

Total Submission: 3

- <http://ivote.io>

# Cloud Resource Allocation & Optimization



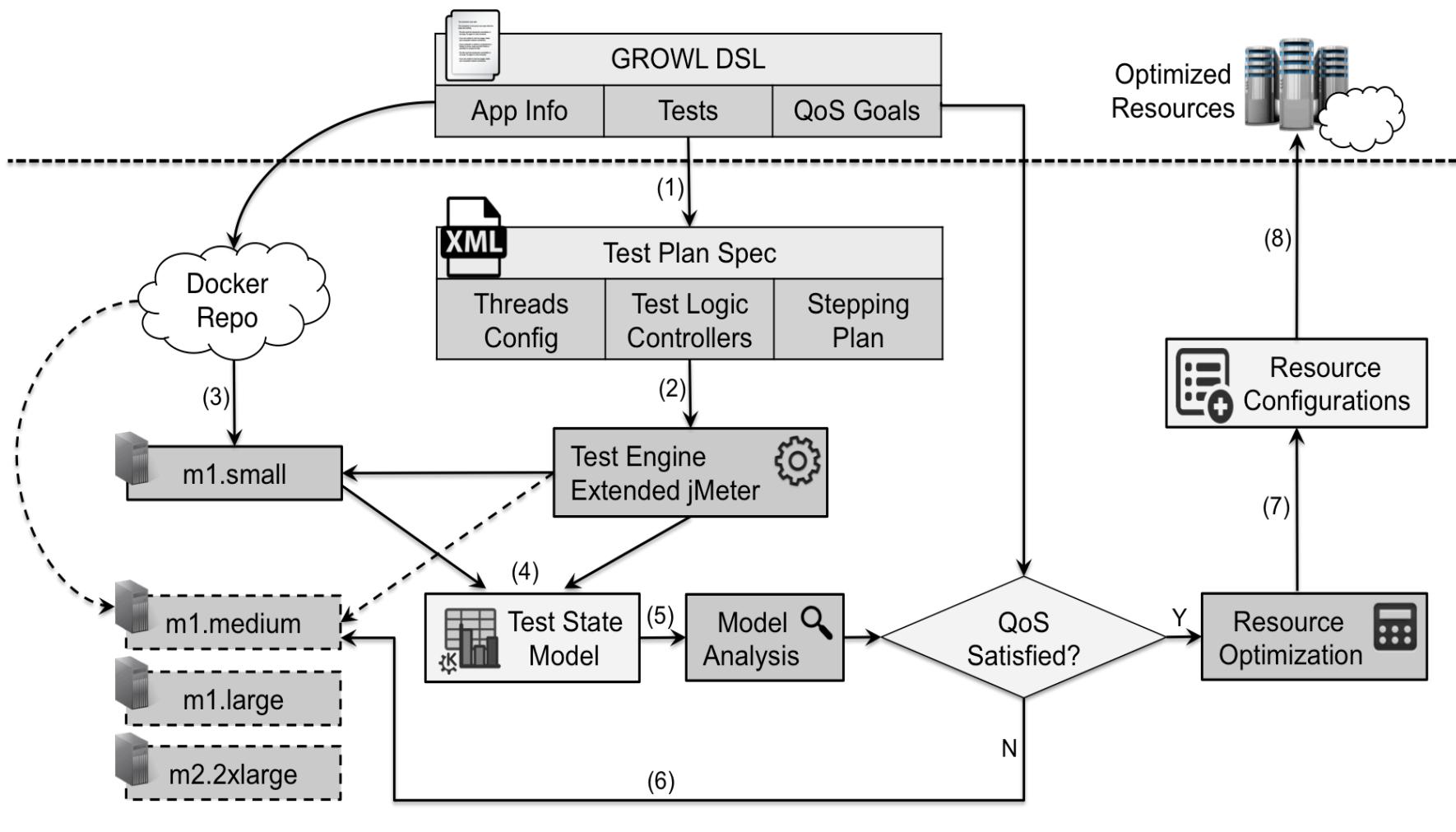
**WEB APPLICATION**

Region	Standard On-Demand Instances	Linux/UNIX Usage	Windows Usage
US - N. Virginia	Small (Default)	\$0.085 per hour	\$0.12 per hour
US - N. California	Large	\$0.34 per hour	\$0.48 per hour
EU - Ireland	Extra Large	\$0.68 per hour	\$0.96 per hour
APAC - Singapore	Micro	\$0.02 per hour	\$0.03 per hour
High-Memory On-Demand Instances			
	Extra Large	\$0.50 per hour	\$0.62 per hour
	Double Extra Large	\$1.00 per hour	\$1.24 per hour
	Quadruple Extra Large	\$2.00 per hour	\$2.48 per hour
High-CPU On-Demand Instances			
	Medium	\$0.17 per hour	\$0.29 per hour
	Extra Large	\$0.68 per hour	\$1.16 per hour
Cluster Compute Instances			
	Quadruple Extra Large	\$1.60 per hour	N/A*

\* Windows is not currently available for Cluster Compute Instances.

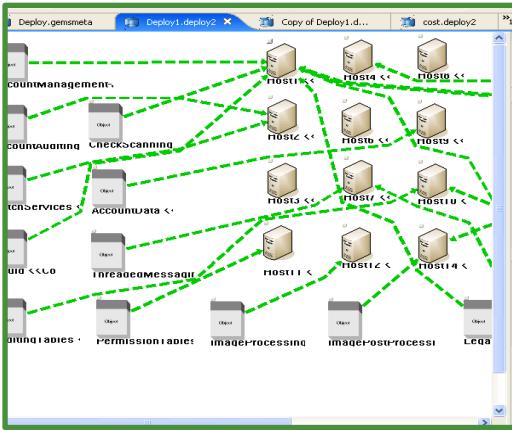


# Cloud Resource Allocation & Optimization



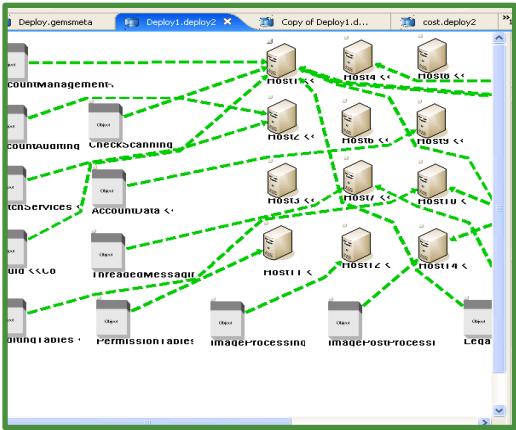
# Summary of My Research Area

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Software Engineering -  
Model-Driven Engineering/  
End-User Programming

# Summary of My Research Area

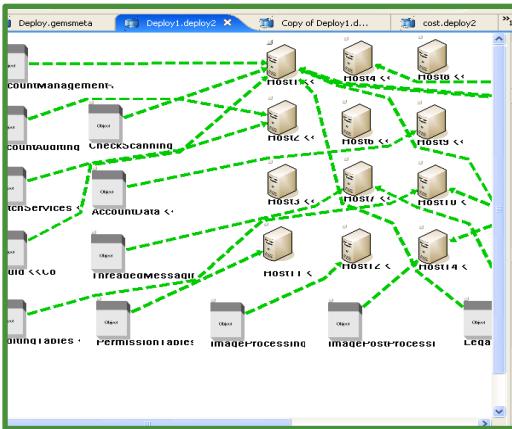


Software Engineering -  
Model-Driven Engineering/  
End-User Programming

Cloud Computing –  
Optimization/Application



# Summary of My Research Area



Software Engineering -  
Model-Driven Engineering/  
End-User Programming

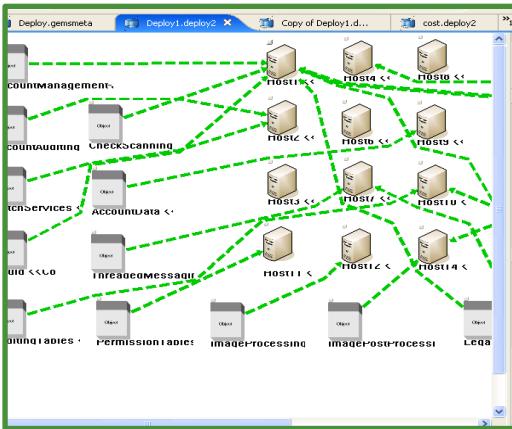
Cloud Computing –  
Optimization/Application



Mobile Computing –  
Augmented Reality/  
Any Cool Applications



# Summary of My Research Area



Software Engineering -  
Model-Driven Engineering/  
End-User Programming

Cloud Computing –  
Optimization/Application

Mobile Computing –  
Augmented Reality/  
Any Cool Applications



My work focuses on using **modeling, optimization, automation & cloud services** to deal with the complexity of domain-specific problems.

# Fast Growing Software Industry

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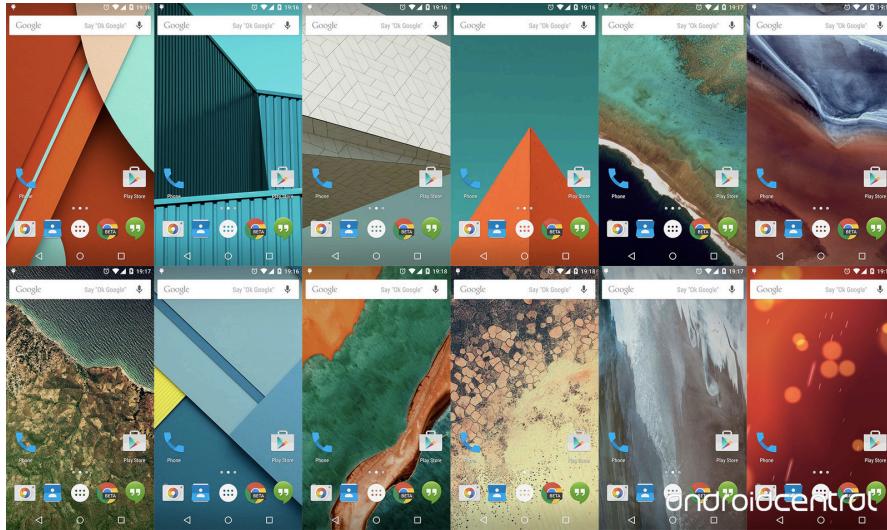


# iPhone 6 & iOS 8

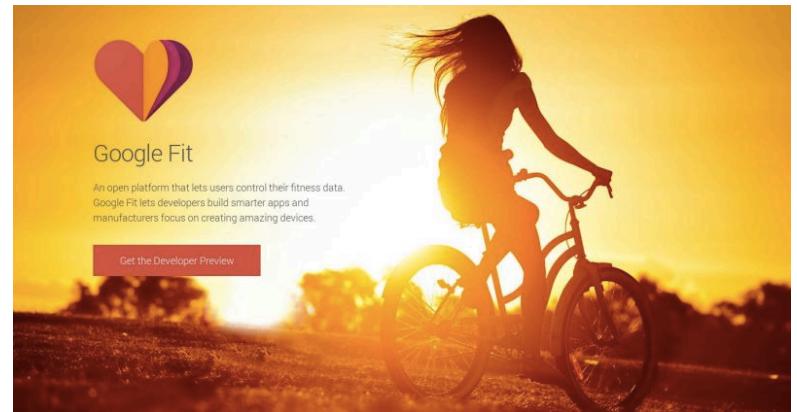
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# Android 5.0 & Google Fit & Android Auto



ANDROID  
5.0



# Amazon Fire Phone & Echo & I-Hour

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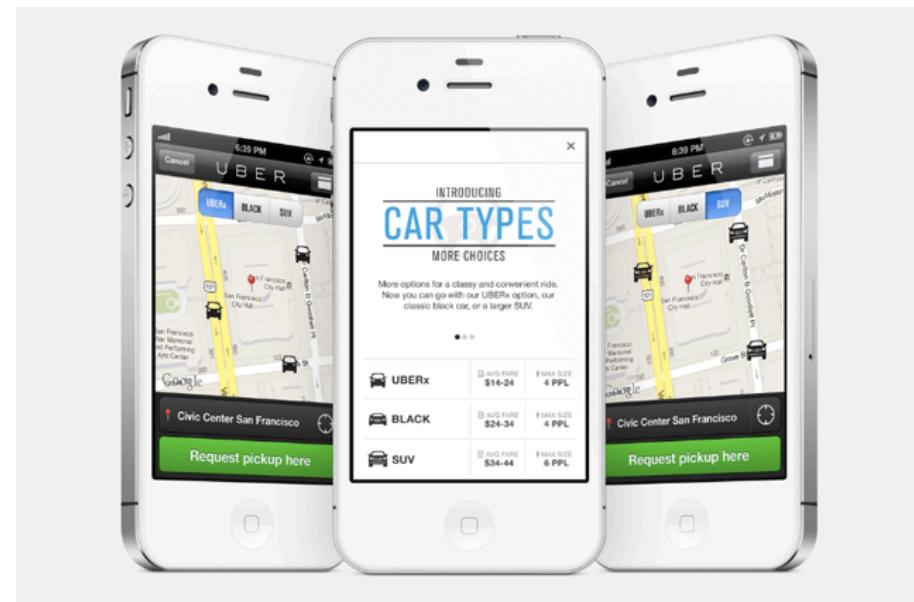


# Uber - \$1.2 Billion Raise

**BREAKING** 3 Big European Oil Companies Get Negative Outlook From S&P Over Price of Crude [TWEET](#)

## Uber Valued at \$40 Billion in \$1.2 Billion Equity Funding

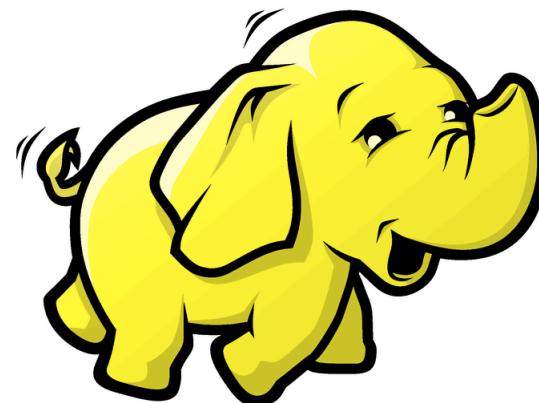
Save + By Serena Saitto | Dec 4, 2014 1:08 PM PT | - [Comments](#) [Email](#) [Print](#)



# Cloudera - \$4 Billion Valuation



**cloudera®**  
Ask Bigger Questions



# Airbnb - \$10 billion Valuation

The screenshot shows the Airbnb search interface for "Queens, NY". On the left is a map of New York City with numerous pink location pins in the Queens area. To the right is a grid of nine Airbnb listing cards for Queen rentals.

**Map View:** Shows the locations of Airbnb rentals in Queens, NY, marked with pink pins on a map of the New York City area.

**Search Results:** 75 Rentals · Queens

**Listing 1:** INCRIDIBLE Deal in HEART of NYC!!!  
Private room  
Ridgewood, Queens  
\$84 Per night

**Listing 2:** Large private bedroom and bath  
Private room  
Astoria, Long Island City  
\$95 Per night

**Listing 3:** Instant Book  
Affordable, private bedroom for you  
Private room  
Jackson Heights, Queens  
\$75 Per night

**Listing 4:** 15 MINUTES to TIMES SQUARE  
Private room  
Astoria, Queens  
\$65 Per night

**Language and Currency:** LANGUAGE AND CURRENCY



# Startup Accelerators

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**500** startups

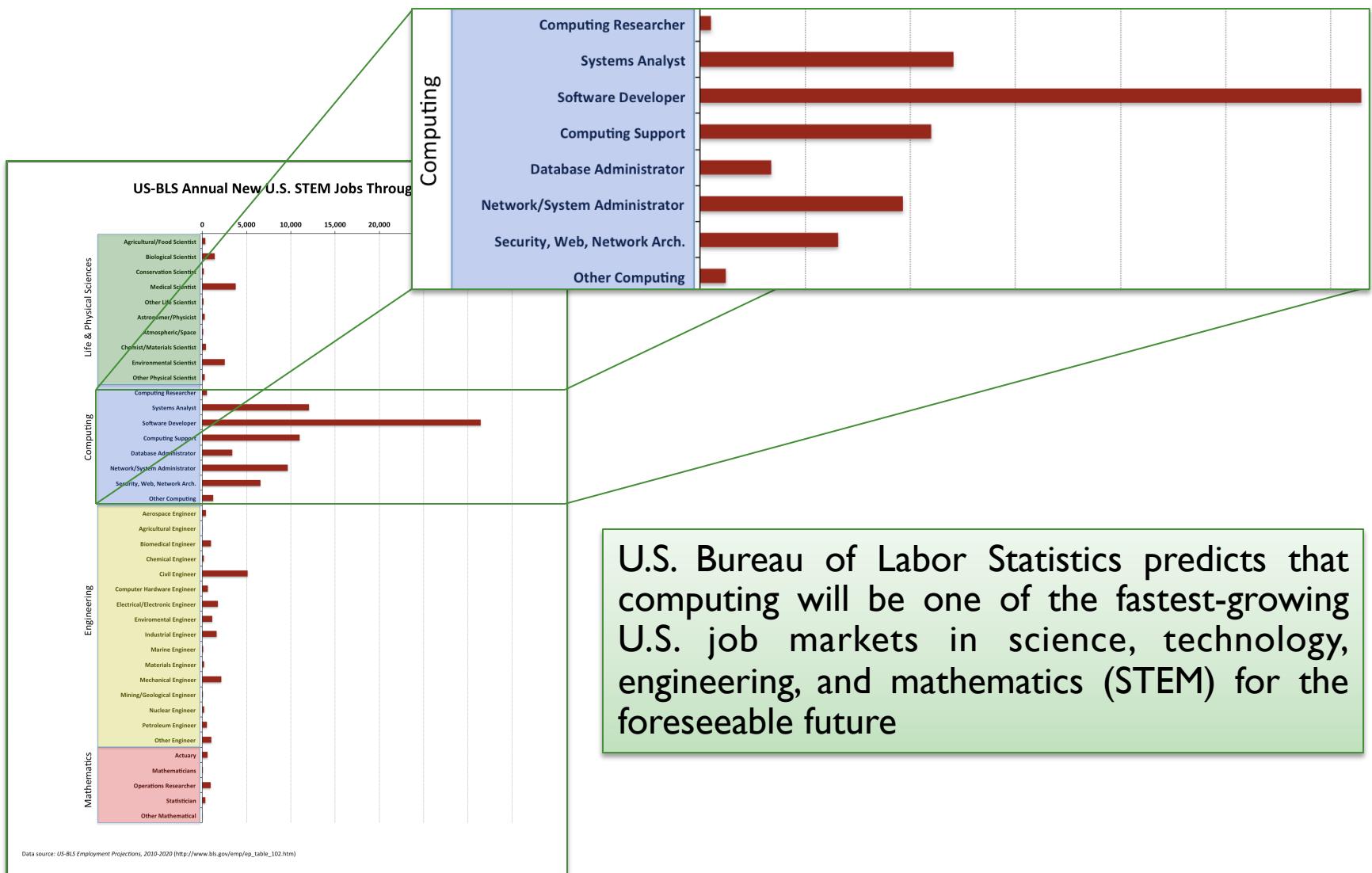


Blueprint for Business



AngelPad

# Software Job Market



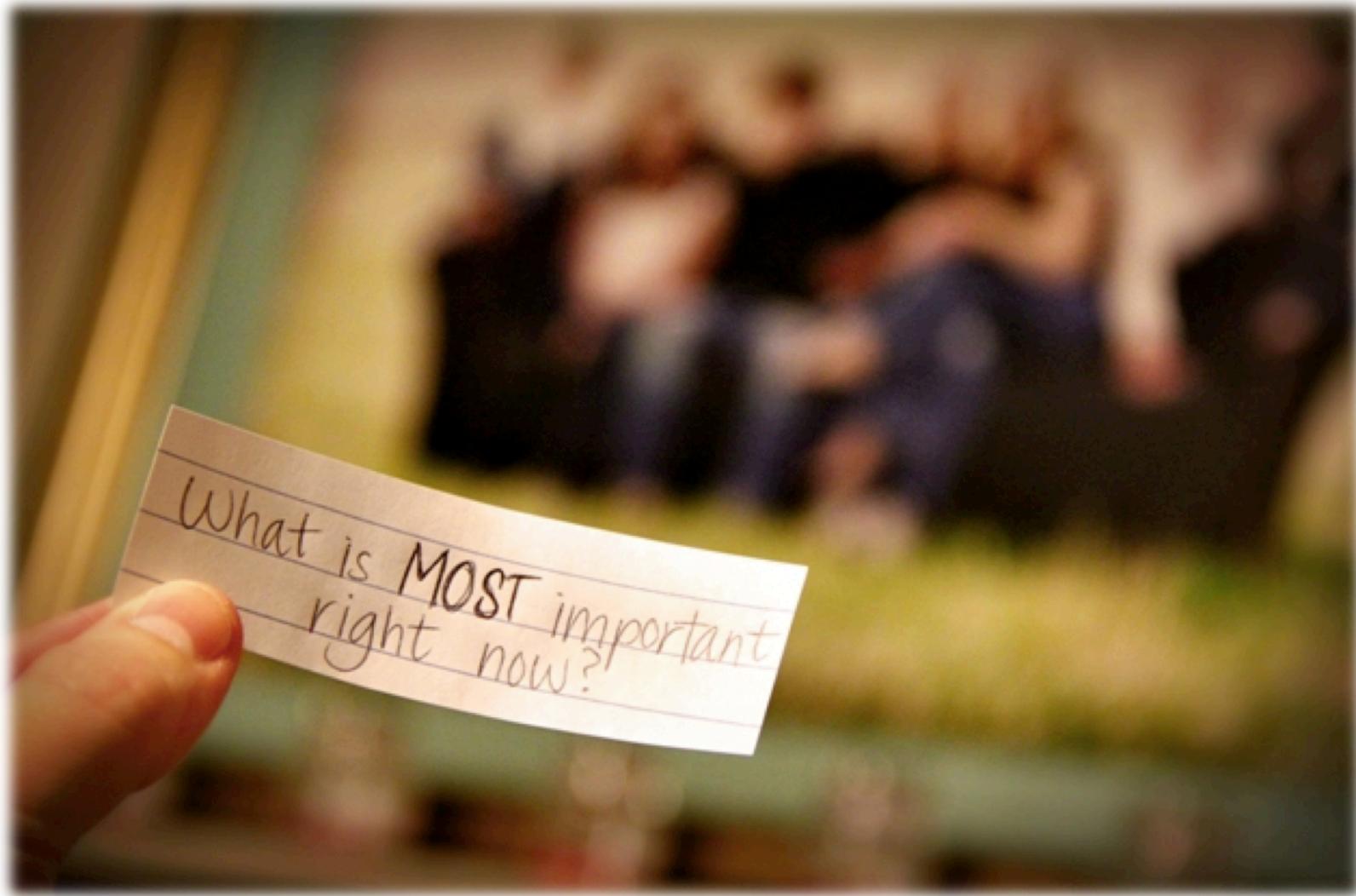
# Fun Place to Work

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# Why is Verification & Validation important?

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# Software Projects are Failing...

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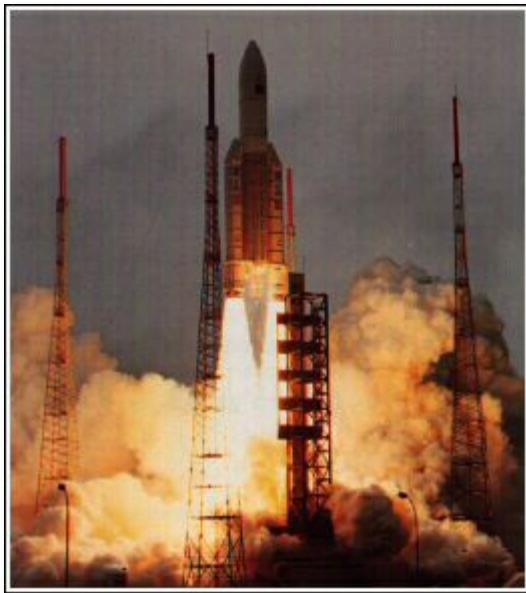
- ◆ A study of 5,400 large scale IT projects (projects with initial budgets greater than \$15M) finds that:
  - ◆ 17 percent of large IT projects go so badly that they can threaten the very existence of the company
  - ◆ On average, large IT projects run
    - ◆ 45 percent over budget
    - ◆ 7 percent over time
    - ◆ 56 percent less value than predicted



- Why do projects fail?
- [http://calleam.com/WTPF/?page\\_id=1445](http://calleam.com/WTPF/?page_id=1445)

# \$7 Billion Fire Works – One Bug, One Crash

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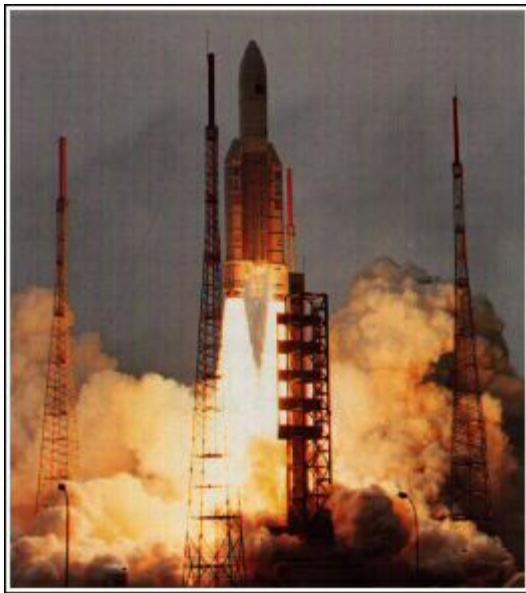


## \$7 Billion Fire Works – One Bug, One Crash

On 4 June 1996, the maiden flight of the Ariane 5 launcher ended in a failure. Only about 40 seconds after initiation of the flight sequence, at an altitude of about 3700 m, the launcher veered off its flight path, broke up and exploded.

The failure of the Ariane 501 was caused by the complete loss of guidance and attitude information 37 seconds after start of the main engine ignition sequence (30 seconds after lift-off). This loss of information was due to specification and design errors in the software of the inertial reference system.

# \$7 Billion Fire Works – One Bug, One Crash



## \$7 Billion Fire Works – One Bug, One Crash

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The failure of the Ariane 501 was caused by the complete loss of guidance and attitude information

“The internal SRI software exception was caused during execution of a data conversion from 64-bit floating point to 16-bit signed integer value. The floating point number which was converted had a value greater than what could be represented by a 16-bit signed integer. This resulted in an Operand Error. The data conversion instructions (in Ada code) were not protected from causing an Operand Error, although other conversions of comparable variables in the same place in the code were protected.”

ignition  
loss of  
design  
reference

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Individuals & Families      Small Businesses      All Topics ▾

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## The System is down at the moment.

We're working to resolve the issue as soon as possible. Please try again later.

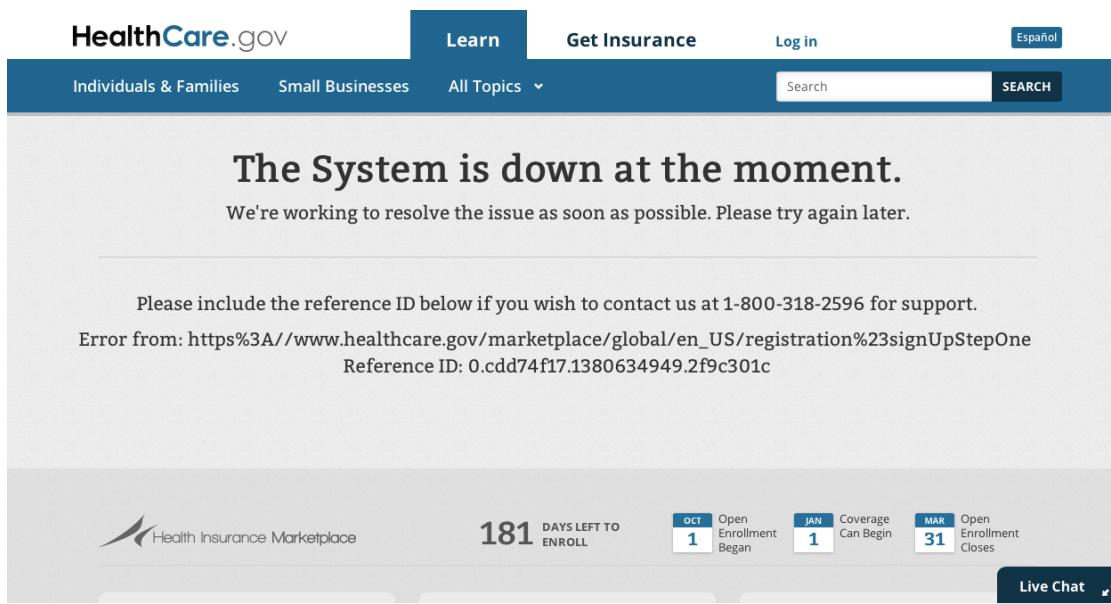
Please include the reference ID below if you wish to contact us at 1-800-318-2596 for support.

Error from: [https://www.healthcare.gov/marketplace/global/en\\_US/registration%23signUpStepOne](https://www.healthcare.gov/marketplace/global/en_US/registration%23signUpStepOne)  
Reference ID: 0.cdd74f17.1380634949.2f9c301c

181 DAYS LEFT TO ENROLL

OCT 1 Open Enrollment Began   JAN 1 Coverage Can Begin   MAR 31 Open Enrollment Closes

Live Chat



- ◆ Estimates that the overall cost for building the website had reached over \$500 million by October 2013
- ◆ Only 1% of people managed to successfully enroll with the site in its first week of operation
- ◆ "There's no sugar coating: the website has been too slow, people have been getting stuck during the application process and I think it's fair to say that nobody's more frustrated by that than I am."

# Universal Credit

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- ◆ Estimates that the overall cost has been over £12.8billion
- ◆ Only one of four planned pilots went ahead according to the original schedule, and this pilot was restricted to extremely simple cases
- ◆ All the benefit calculations had to be done manually in spreadsheets, which implied that only the digital forms part of the system was working correctly
- ◆ A maximum of 25,000 people – just 0.2% of all benefit recipients – will be transferred onto Universal Credit by the next general election in 2015

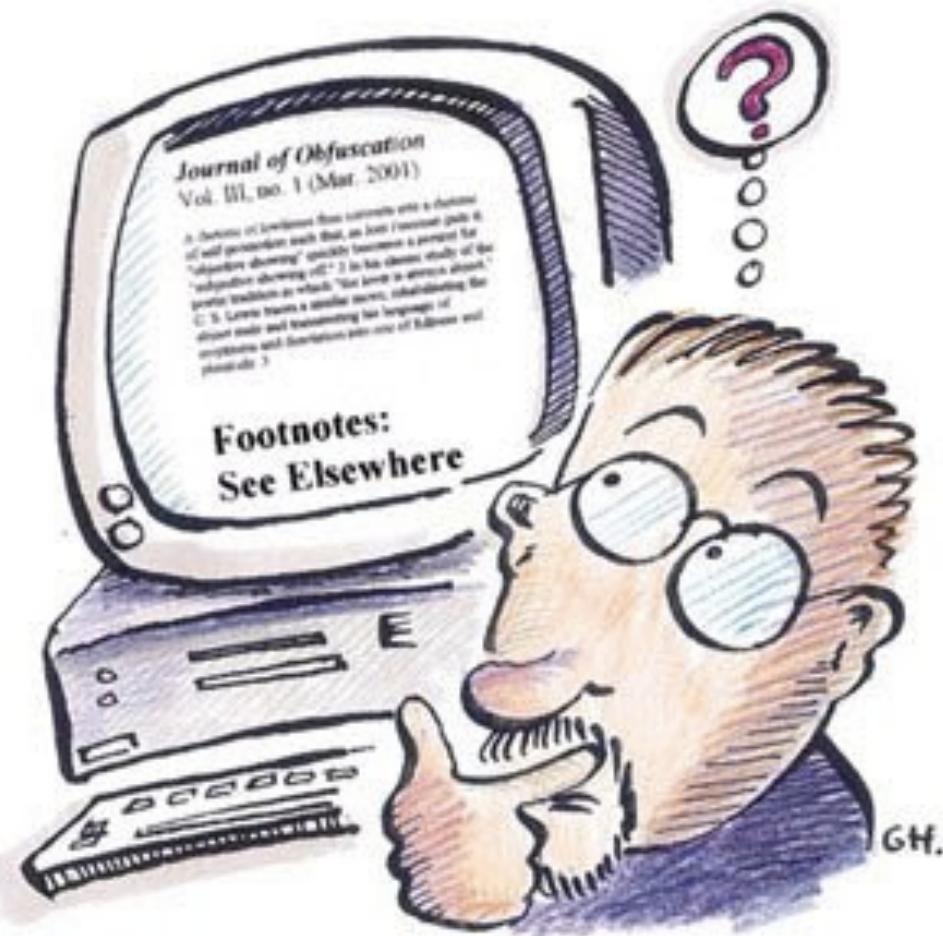
# U.S. Air Force Pulls Plug on \$1B ERP Project

- ◆ U.S. Air Force had decided to scrap a major ERP software project after it racked up **\$1 billion** in expenses but failed to create "any significant military capability."
- ◆ The system was supposed to replace more than 200 legacy systems. The project dated to 2005, but An Air Force spokesman said the project would require **another \$1.1 billion** just to complete **one-fourth** of the original scope, and that wouldn't be complete until 2020.
- ◆ The U.S. Department of Defense latest strategy for putting lipstick on a pig, when faced with a major project debacle, has been to say, "Well, it's not a total waste because the effort creates an opportunity to harvest technologies and lessons learned."



# What is Verification & Validation?

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# Basic Definitions of V&V

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- ◆ “In software project management, software testing, and software engineering, **verification and validation** (V&V) is the process of checking that a software system meets specifications and that it fulfills its intended purpose. It may also be referred to as software quality control.”

# Basic Definitions of V&V

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- ◆ “Software **verification** provides objective evidence that the design outputs of a particular phase of the software development life cycle meet all of the specified requirements for that phase by checking for consistency, completeness, and correctness of the software and its supporting documentation.”
- ◆ “**Validation**, on the other hand, is the confirmation by examination and provision of objective evidence that software specifications conform to user needs and intended uses, and that the particular requirements implemented through software can be consistently fulfilled.”

# Basic Definitions of V&V

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## ◆ Golden Rules

Have we built the software right?

# Verification and Validation

Have we built the right software?

# One of the Major SE Research Areas

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# Research in Software Testing, V&V

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- ◆ Testing theory and practice
- ◆ Testing in globally-distributed organizations
- ◆ Model-based testing
- ◆ Model-driven development and testing
- ◆ Domain specific testing
- ◆ Security testing
- ◆ Web-service testing
- ◆ Database testing
- ◆ Embedded software testing
- ◆ Testing concurrent software
- ◆ Testing large-scale distributed systems
- ◆ Testing in multi-core environments
- ◆ Validation testing
- ◆ Quality assurance
- ◆ Model checking
- ◆ Metrics and Empirical studies
- ◆ Fuzzing
- ◆ Inspections
- ◆ Testing and analysis tools
- ◆ Design for testability
- ◆ Testing education
- ◆ Technology transfer in testing
- ◆ Agile/iterative/incremental testing processes
- ◆ Testing of open-source third-party software
- ◆ Software reliability
- ◆ Performance and QoS testing
- ◆ Standards
- ◆ Formal verification
- ◆ Experience reports

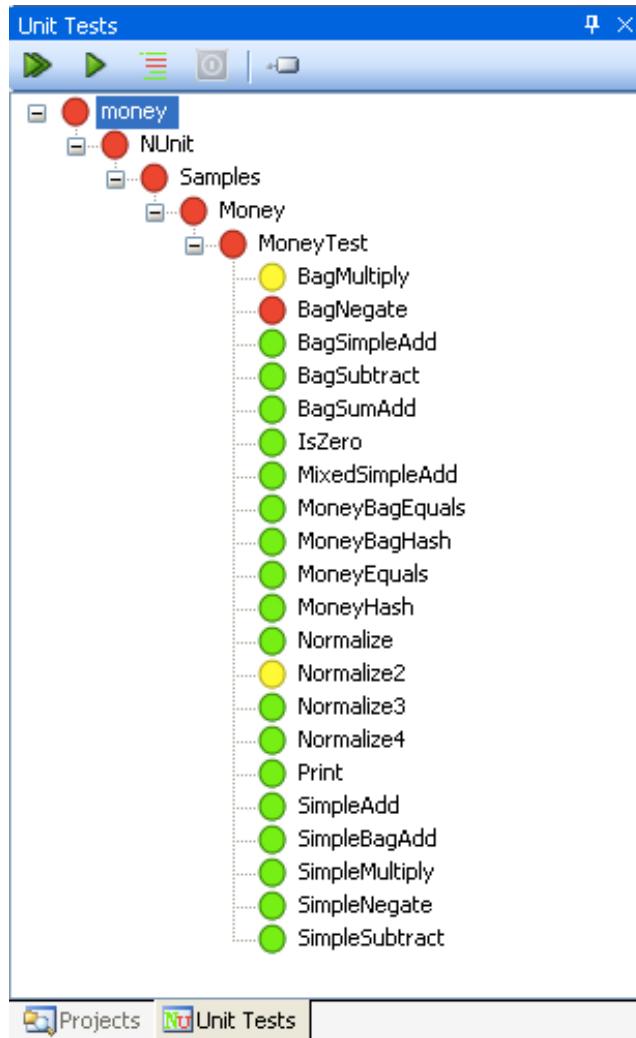
# What's V&V in Practice?

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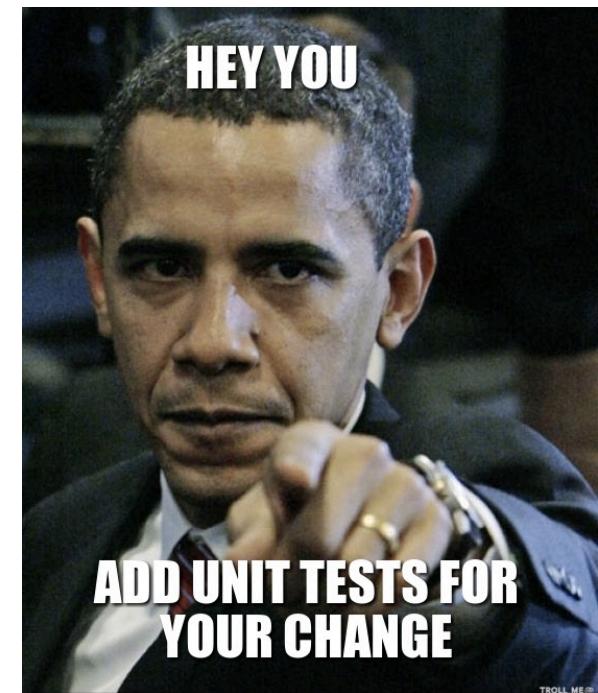


# Unit Test

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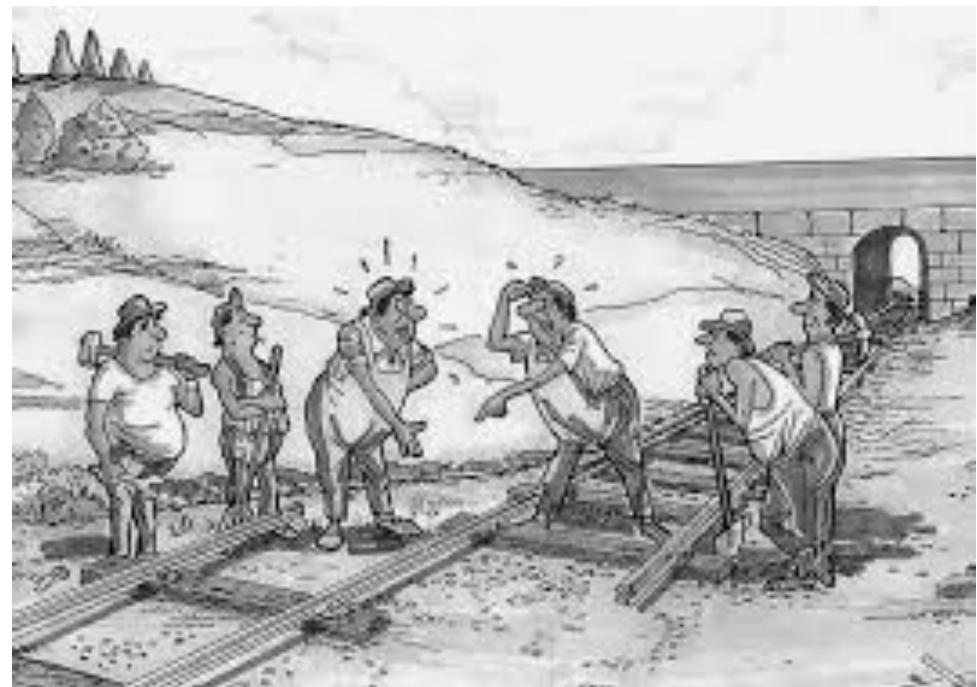
- ◆ You are required to write Unit Tests for all your changes before checking in



# Integration Test

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- ◆ Integration testing is the phase in software testing in which individual software modules are combined and tested as a group

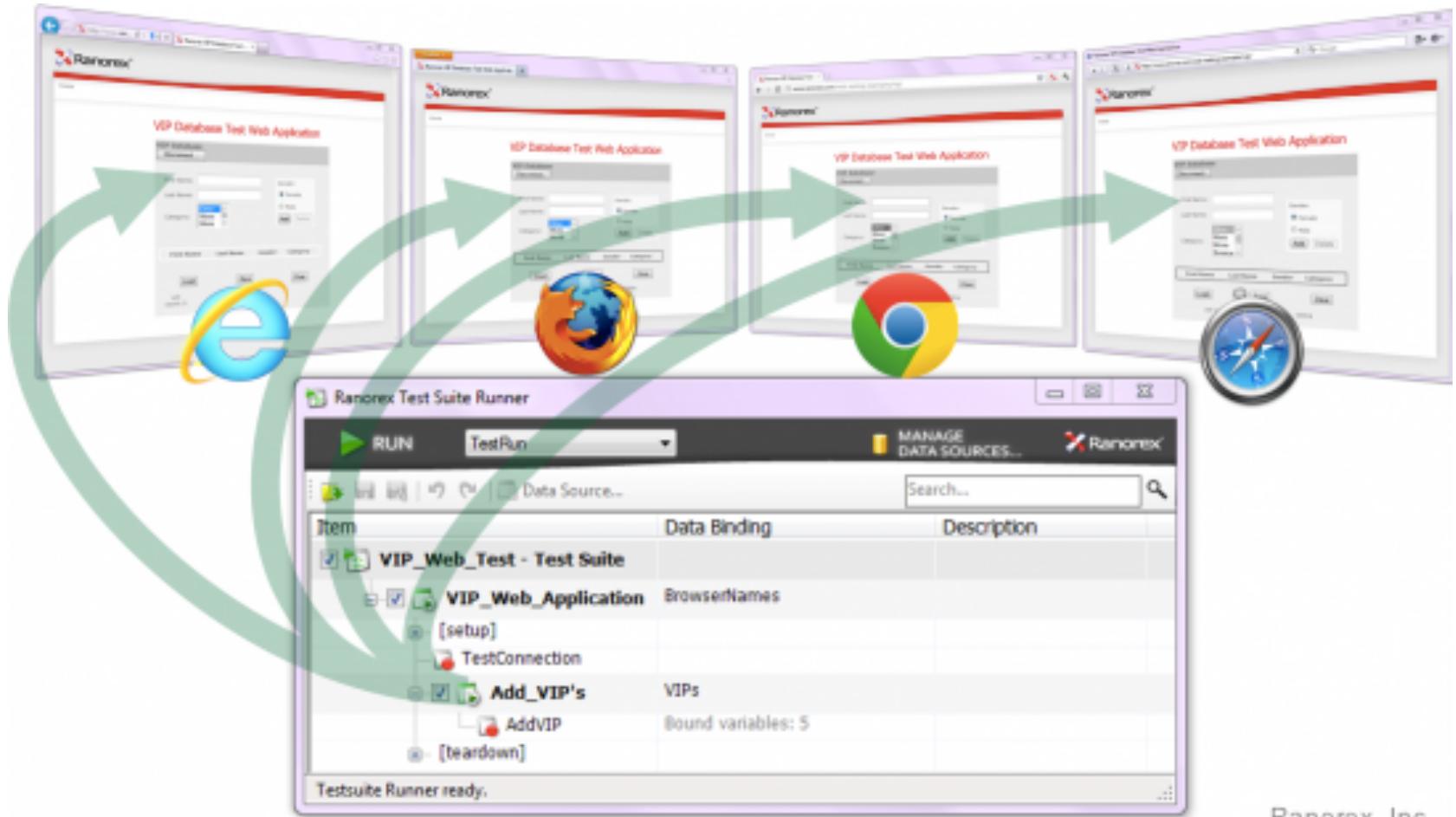


# Test Automation & Continuous Integration

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# System Verification - Function

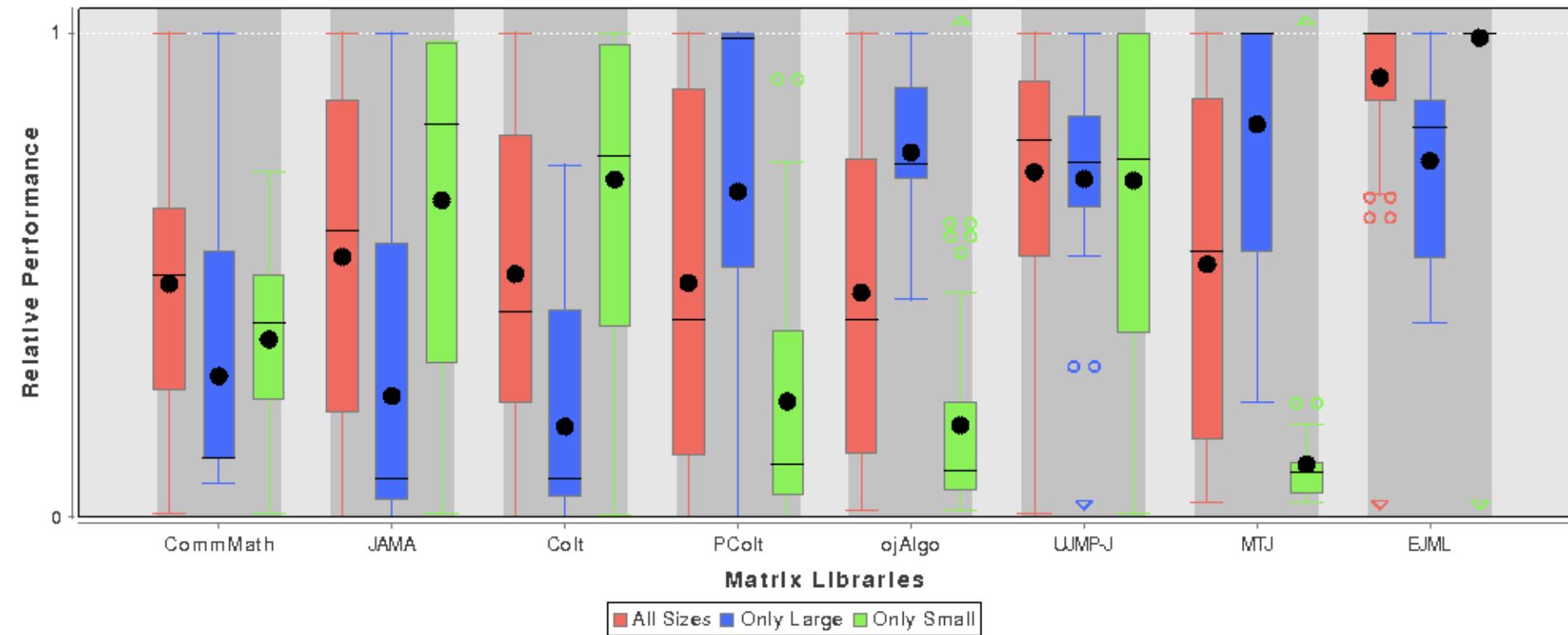


Ranorex, Inc.

# System Verification - Performance

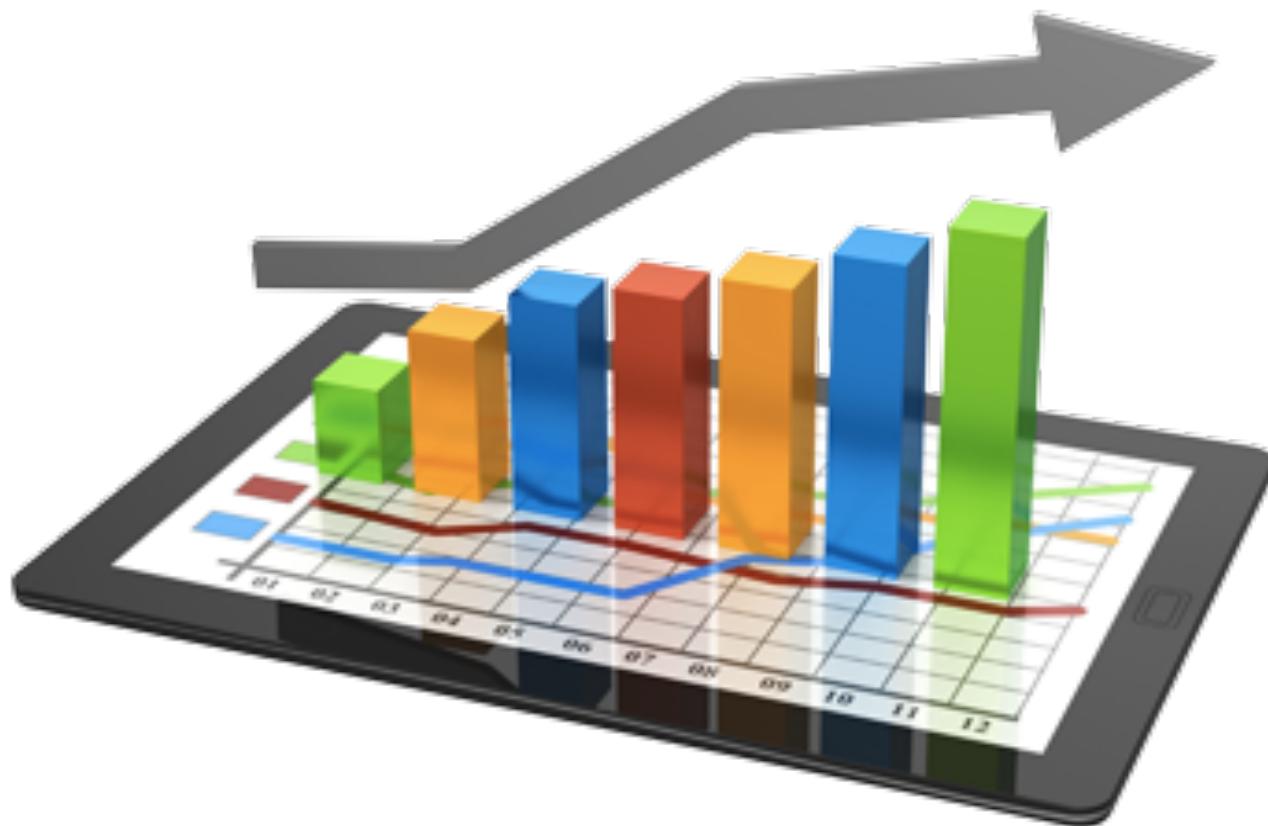
## Summary of Runtime Performance

( Higher is Better ) ( Weighted by Operation Time )



# System Verification - Scalability

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# System Verification - Compatibility

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MAJOR BROWSER  
**COMPATIBILITY**



Made for

iPod iPhone iPad



iOS



Compatible with all Operating Systems  
supporting Bluetooth SPP

# System Verification - Monitoring

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# The Most Effective – Manual Verification

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# About CS585

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# The Syllabus

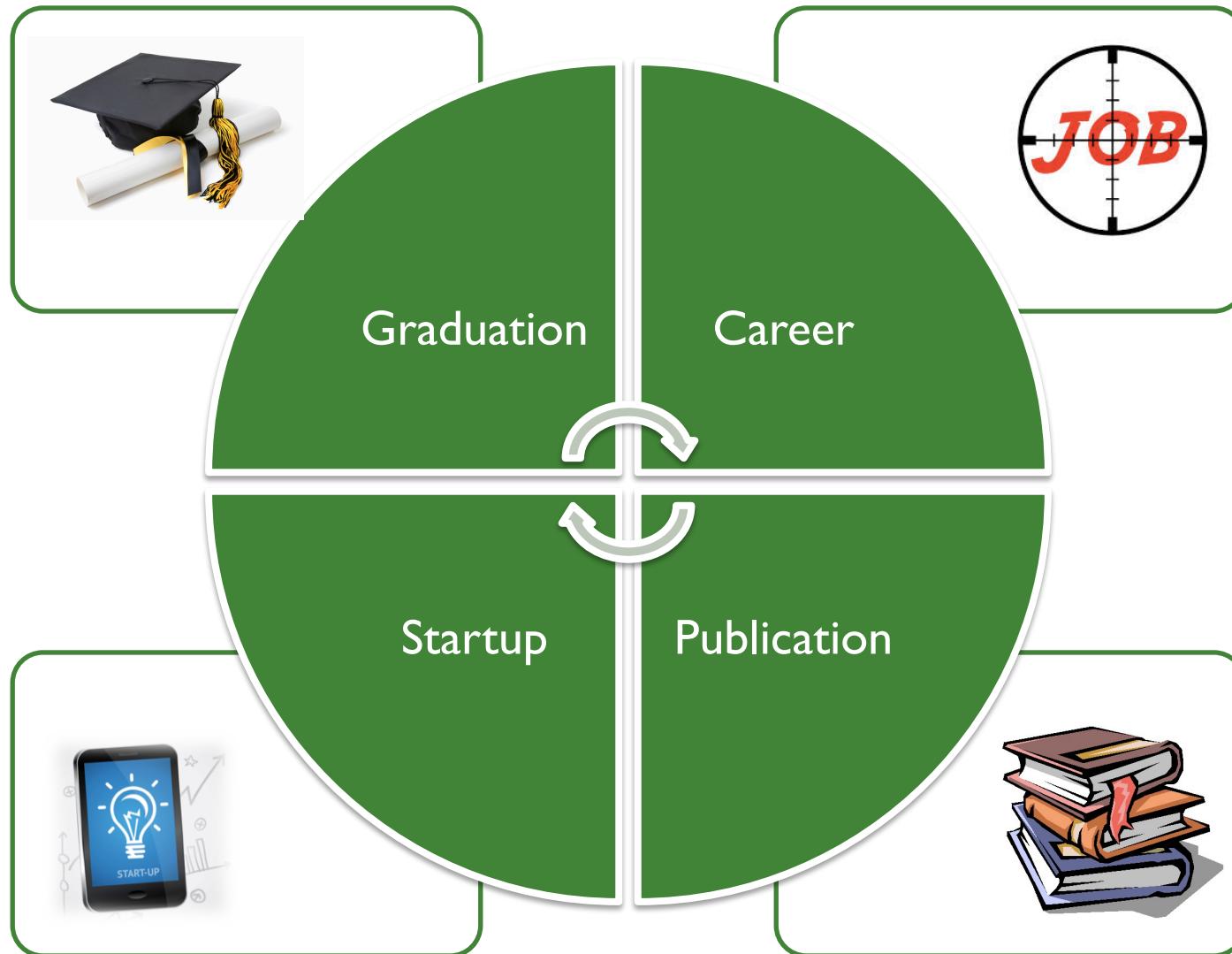
# Goals

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- ◆ Be Practical
  - ◆ Learn the testing/verification/validation skills and practices needed as a software engineer
- ◆ Be Researchy
  - ◆ Learn how to do research and get ready for your Master project/thesis

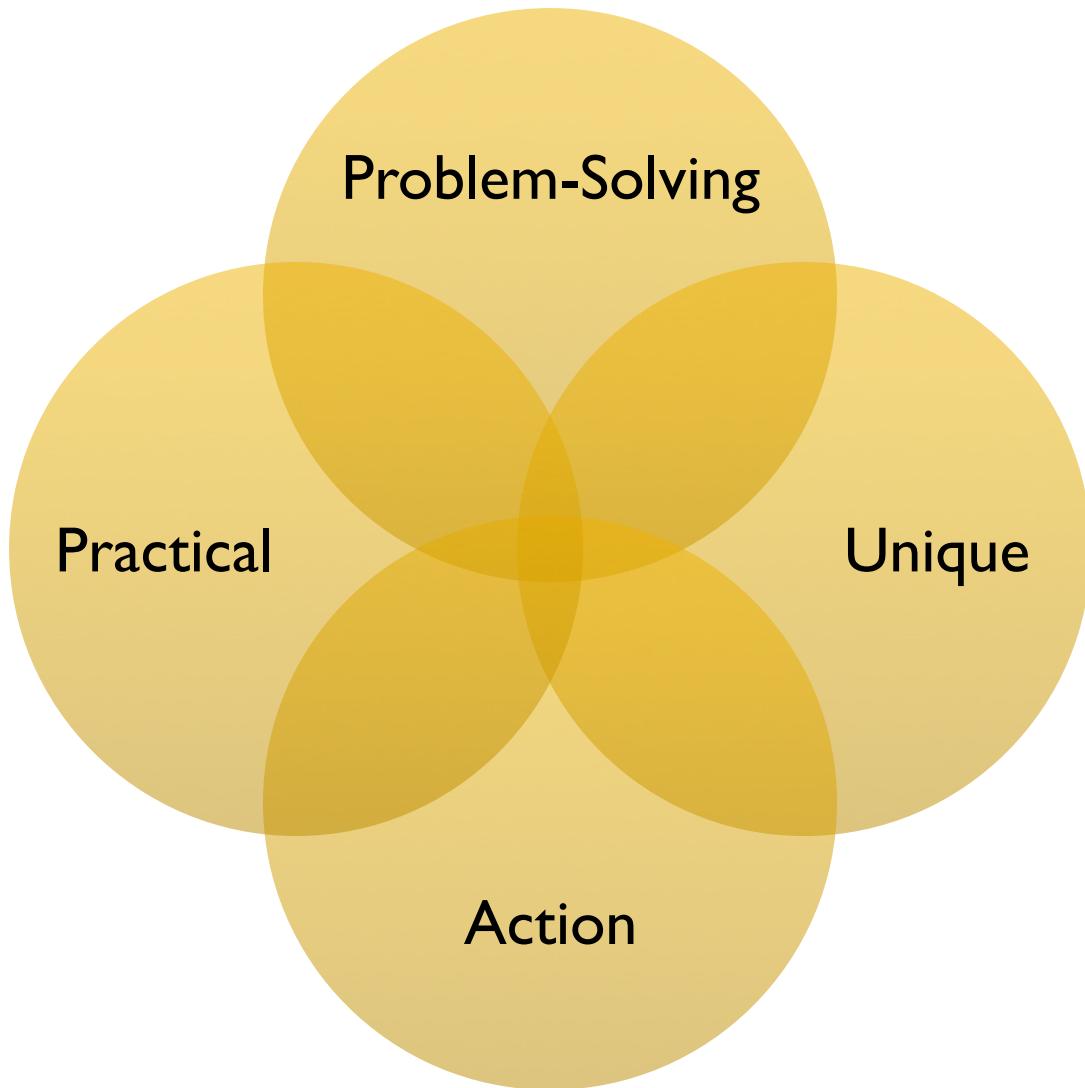


# What is a Good Student Project?



# How to Build a Good Project?

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# Research Topics

# I. Automated Test Generation

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- ◆ Automatically generate unit/integration test cases, code, configurations, etc.
  1. From HTTP API Specification to Integration Tests
  2. From HTML Page to Selenium Tests
  3. From Android UI XML Specification to Unit Tests
  4. From iOS UI Specification to Unit Tests



## 2. Automated Grading

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- ◆ Automated approaches to assist large-scale grading for computer science education
  - 1. Use Continuous Integration to Support Auto-Grading
  - 2. Java Annotation-based Automated Grade Reporting
  - 3. GitHub Repo Clone Detection



Transform your grading process!

# 3. Static Code Analysis

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- ◆ Automatically Analyze the source code to support program comprehension, verification and validation

## I. Design Pattern Verification



# 4. Mining-based Testing

- ◆ Provide testing support through data mining, big data techniques

1. Tester Evaluation
2. Test Start Finder



# 5. Mobile Testing

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- ◆ Special testing techniques for mobile platform

1. Android Test Bed using Genymotion
2. Mobile GUI User Behavior Checker



# 6. Web Testing

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- ◆ Special testing techniques for web platform

1. Web GUI User Behavior Checker
2. Browser Compatibility Checker
3. Web UI Reporting



# 7. Performance Testing/Validation

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- ◆ Test and validate the performance for web services
  - 1. Generic Monitor/Alarm Web Service
  - 2. Annotation-Based HTTP API Latency Metrics and Auto Alarm
  - 3. QoS-Based Unit Testing



# 8. Software Security

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## ◆ Software and web security techniques

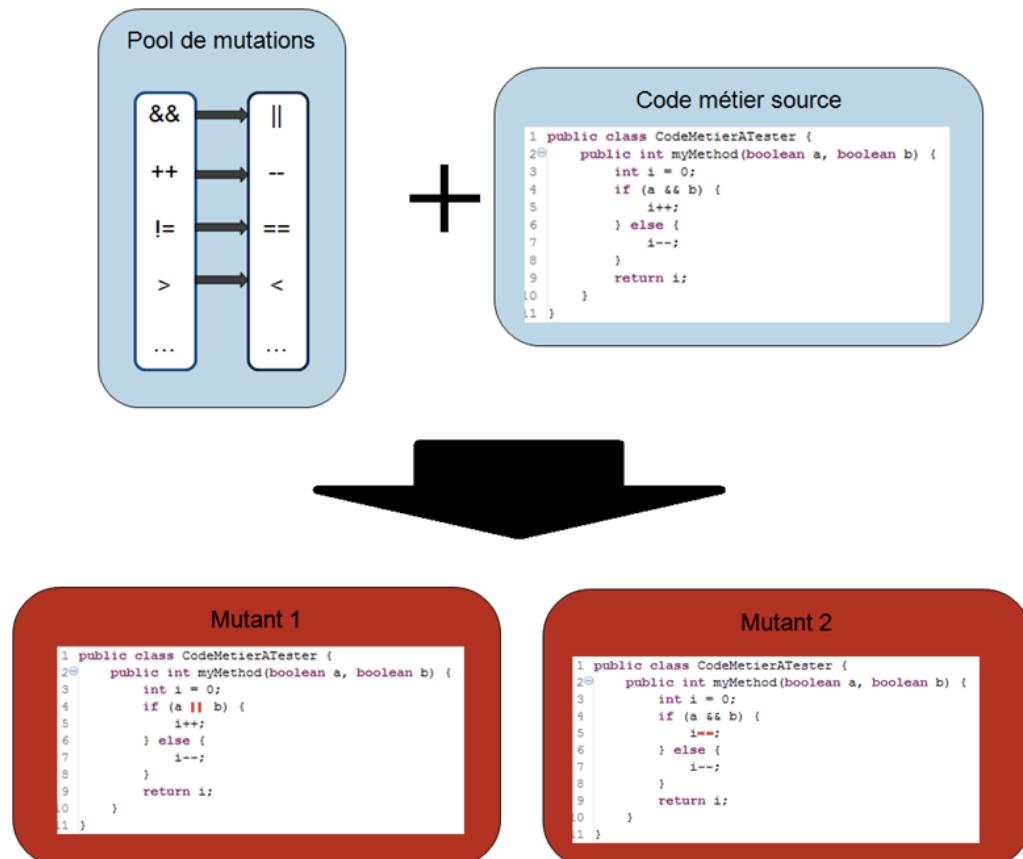
1. DDoS Attack Service
2. DDoS Identification & Recovery



# 9. Mutation-based Testing

- ◆ Evaluate the quality of test by modifying a program in small ways

## I. Automated Test Quality Evaluation



# 10. GitHub-related Testing

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- ◆ Perform testing based on GitHub platform and APIs

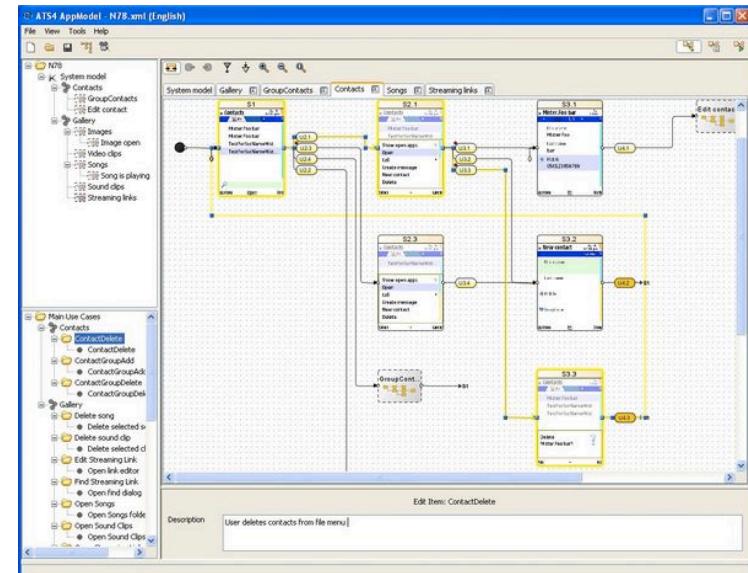
- I. Automated Developer Feedback on Test



# III. Model-based Testing

## ◆ Testing techniques by utilizing software models

1. Test Generation from System Models
2. High-level Test Model Specification



# TODO

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- ◆ Read and think about your project topic