

(Dis) Integrated Systems

Awais Rashid





© A. Rashid 2008



An Apology



LANCASTER UNIVERSITY





- Laureate of the Pays de la Loire Regional Chair at Ecole des Mines de Nantes, 2008-2011
- Coordinator of European Network of Excellence on Aspect-Oriented Software Development





LANCASTER



- Leading a number of projects on taming complexity of software-based systems
 - Aspect-oriented software development
 - Model-driven engineering
 - Software product line engineering
 - Software engineering in ethically challenging contexts
- Author of several scholarly articles, books, book chapters, etc. in the above areas over the years





LANCAS





- Dr. Ruzanna Chitchyan, Dr. Paul Rayson, Mr. Americo Sampaio
- A long term collaboration has no doubt also influenced some of the ideas:
 - Dr. Ana Moreira, Dr. Joao Araujo (New University of Lisbon, Portugal)





LANCASTE



From Large-Scale Systems to Systems-of-Systems







Extreme Complexity

- Heterogeneity
- Dynamicity
- Ultra large-scale
- Socio-technical nature
- Needs reconsideration of a number of fundamental software engineering mechanisms





LANCAS



- Abstraction across heterogeneous and dynamic contexts
- **Composition** that crosses organisational, platform, system administration and geographical boundaries
- End-to-end preservation of business, economic, social and technical goals





LANCAS



Are we meeting these challenges today?









Awais' Trip to Genoa









Heathrow Terminal 5









Emergent requirements and new contexts









The **goal-goal dichotomy** – individual vs. team goals







Modular Reasoning

Keep concerns separated regardless of how they affect or influence various other concerns in the system, so that we can reason about each concern in isolation

> Adapted from: Kiczales, Mezini: "Aspect-Oriented Programming and Modular Reasoning", Proc. ICSE 2005





LANCASTE



Compositional Reasoning

Understand the dependencies and interactions amongst concerns to reason about the global or emergent properties of the system

Adapted from: Rashid, Moreira: "Domain Models are NOT Aspect Free", Proc. MoDELS 2006.







In Compositional Reasoning lies the key to improved system-of-system integration









How to reason about requirements interdependencies for a system-of-systems?









Approx. 80% of requirements specifications are in natural language







What does a requirements engineer do?

Reconcile multiple views of concerr technica capitalia Identify variations on a theme to reconcile differing views of the same concept





LANCASTER

Trade-off Analysis

- Basic questions
 - Are the solutions that are being suggested as good as possible?
 - How much must I give up to get a little more of what I want most?
- How can we define a good / better outcome?
 - Reduced time of response
 - Improved security access
 - Increase number of clients being served simultaneously





LANCAS





- What can actually be done given reality and resource constraints?
- What commonalities and variations make sense?





LANCASTER



- Natural language processing and information retrieval techniques have made great strides over the last two decades
- Example: Lancaster Wmatrix Natural Language Processor: Accuracy of 97% for part-of-speech analysis and 93% for semantic analysis





LANCASTER



But are these enough to reason about interdependencies in a system-of-systems?







Cross-language Dependency Analysis

- Work on natural language semantics can help explore heterogeneous documents
- But our own experience so far is only in English
- In the increasingly global environment this is an unrealistic constraint
- Yet languages often do share some common structure, e.g., Latin-based languages
- Need to develop cross language dependency analysis
 using semantic queries
- Need to complement NLP with IR techniques to uncover latent similarity amongst documents





LANCASTEF



- A challenging problem that requires us to
 - Go beyond traditional software engineering philosophies
 - Draw upon knowledge/experience from a range of disciplines, e.g., psychology, social sciences, etc.
 - Rethink our notions of consistency





LANCAS

Questions?







