Service-Oriented Computing

CSC 450 and CSC 750

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Fall 2019

Bio Highlights and Humble Bragging

- Students
  - Graduated PhD: 27; MS: 32
  - Inaugural Alumni Hall of Fame: Nirmit Desai, Pınar Yolum
  - Inaugural Faces of Computer Science (EB2 hall): Chris Hazard
  - Associate Editors: Amit Chopra, Michael Maximilien, Pınar Yolum
  - CGS MS Thesis Award: Payal Chakravarty; also, nominee: Anup Kalia
  - Dept awards. 2019: Nirav Ajmeri; 2017: Nirav Ajmeri, Hui Guo, Pradeep Murukannaiah; 2016: Pradeep Murukannaiah
- NCSU Internal
  - Alumni Distinguished Graduate Professor
  - Research Leadership Academy
  - Outstanding Research Achievement Award
- External
  - Fellow, Association for the Advancement of Artificial Intelligence
  - Fellow, Institute of Electrical and Electronics Engineers
  - Influential Paper Award, IFAAMAS
  - Editor in Chief
    - ACM Transactions on Internet Technology, 2012–2018
    - IEEE Internet Computing, 1999–2002

My Goal and Request for Your Help

- Introduce you to deep concepts, some years in the making in the research and advanced development community
- Introduce you to critical thinking
- Boost your confidence in taking on technical challenges
  - You might hesitate to take on otherwise
  - Your peer group might find overwhelming
- Offer free advice (worth every penny^{SM}) about your
  - Education
  - Career
- How you can help
  - Don't take ethically dubious actions
  - Stay engaged
  - Communicate with me personally, especially about
    - Explanations and motivations
    - Improvements to the course, in general

Mechanics

- Scope
- Grading
- Policies
  - Especially, academic integrity
  - Don't help; don't take help; don't collude

Scope of this Course

- Directed at computer science students
- Addresses service-oriented computing, emphasizing how it differs from typical forms of computing
  - Emphasizes concepts and theory
  - Involves tools in assignments
- Requires a moderate amount of work
  - Fairly easy if you don't let your tasks slip

Bloom's Taxonomy of Learning Domains (Cognitive)

I emphasize the upper categories

Creating	Build new structures
Evaluating	Make judgments
Analyzing	Identify elements
Applying	Use on a problem
Understanding	State in own words
Remembering	Recall

- http://www.nwlink.com/~donclark/hrd/bloom.html

Highlights

- Visions for the Web
- Open environments
- Services
- Main themes of this course
    - Information and its meaning
    - Decentralization of computation
    - Applying standards and tools where appropriate

Historical View on Computer System Architectures

Central ⇒ Client-Server ⇒ Peer-to-Peer ⇒ Multiagent Systems

The Web

- Initially, and still primarily, designed for people
  - Focuses on presentation
  - People provide the meaning: no formal representation
- Low-level interactions
  - Client-server
  - Stateless
  - Focus on procedures across websites that cause avoidable coupling

The Service Web

- Support interactions among providers and consumers
  - Beyond presentation to representation of content
  - From plain representation of content to richer meanings
  - Ways of structuring complex activities
  - Ways for independent components to interoperate
  - Ways to share contextual information

Service Composition

- Providers build and launch services
- The services are understood by prospective consumers
- Consumers can discover and select suitable services
- Consumers put selected services together to create value and possible launch their compositions as new services

Electronic Business

- B2C: retail, finance
- B2B: supply chains (more generally, supply networks)
- Different perspectives
  - Traditionally: merchant, customer, dealmaker
  - Trends: collaboration among various parties; virtual enterprises; coalition formation
  - Challenge: how to cut across different perspectives

Main technical consequence: interacting across enterprise boundaries or administrative domains

Properties of Business Environments

- Traditional computer science deals with *closed* environments
- Business environments are *open*
  - Autonomy: independent action (how will the other party act?)
  - Heterogeneity: independent design (how will the other party represent information?)
  - Dynamism: independent configuration (which other party is it?)
    - Usually, also large scale
- Requirements
  - Going from one locus of control to multiple loci of control
  - Supporting flexible interaction and arms-length relationships

Open Environments can Arise Outside of Business

Exercise: think of some examples

- Collaborative scientific computing
- Natural disaster recovery
- ...

Autonomy

Independence of business partners

- Sociopolitical or economic (commonsense) reasons
  - Ownership of resources by partners
  - Control, especially of access privileges
  - Payments
- Technical reasons: opacity with respect to key features, e.g., precommit
- Encapsulate: Model components as autonomous to
  - Simplify interfaces "assume nothing"
  - Accommodate any underlying exceptions

Heterogeneity

Independence of component designers and system architects

- Historical reasons
- Sociopolitical reasons
  - Differences in local needs
  - Difficulty of achieving agreement
- Technical reasons: difficulty in achieving homogeneity
  - Conceptual problems: cannot easily agree
  - Fragility: a slight change can mess it up

Dynamism

Independence of system configurers and administrators

- Sociopolitical reasons
  - Ownership of resources
  - Changing user preferences or economic considerations
- Technical reasons: difficulty of maintaining configurations by hand
  - Same reasons as for network administration
  - Future-proofing your system

Coherence

Fitting well with each other: An alternative to consistency

- There may be no state (of the various databases) that can be considered consistent
  - Maintaining consistency of multiple databases is difficult
  - Unexpected real-world events can knock databases out of sync with reality
- What matters is
  - Are organizational relationships preserved?
  - Are processes followed?
  - Are appropriate business rules applied?

Integration

Becoming one

Yields with *one* integrated entity

- Yields central decision making by one homogeneous entity
- Requires resolving all potential inconsistencies ahead of time
  - Freeze Org policies into computational system
- Fragile and must be repeated whenever components change

Obsolete way of thinking: *tries* to achieve consistency (and fails)

Locality and Interaction

A way to maintain coherence in the face of openness

- Have each local entity look after its own
  - Minimize dependence on others
  - Continually have interested parties verify the components of the state that apply to them
- Approach: (to the extent possible) replace global constraints with protocols for interaction
  - *Lazy:* obtain global knowledge as needed
  - *Optimistic:* correct rather than prevent violations
  - *Inspectable:* specify rules for when, where, and how to make corrections

Interoperation

Working together

Ends up with the *original number* of entities working together

- Yields decentralized decision making by heterogeneous entities
- Resolves inconsistencies incrementally
- Potentially robust and easy to swap out partners as needed

Also termed "light integration" (bad terminology)

Example: Selling

Update inventory, take payment, initiate shipping

- Record a sale in a sales database
- Debit the credit card (receive payment)
- Send order to shipper
- Receive OK from shipper
- Update inventory

Potential Problems Pertaining to Functionality

Scenarios that would lead to inconsistency

- What if the order is shipped, but the payment fails?
- What if the payment succeeds, but the order was never entered or shipped?
- What if the goods arrive damaged?

Architectural Considerations

Architecture is motivated by additional considerations besides functionality

- Instance level, nonfunctional properties such as the availability of a specific service instance
  - What if the payments are made offline, i.e., significantly delayed?
- Metalevel properties such as the maintainability of the software modules and the ease of the upgradability of the system

In a Closed Environment

- Transaction processing (TP) monitors ensure that all or none of the steps are completed, and that systems eventually reach a consistent state
- But what if the user is disconnected right after he clicks on OK? Did the order succeed? What if line went dead before acknowledgment arrives? Will the user order again?
- The TP monitor cannot get the user into a consistent state
  - Impossibility of ensuring consistency and progress in an open setting

In an Open Environment: 1

- Fundamental need
  - Model the rules of encounter among the parties
  - Matter of policies to ensure compliance
  - Engage user about credit problems
- Underlying assumptions and approach
  - Reliable messaging (asynchronous communication, which guarantees message delivery or failure notification)
  - Maintain state: retry if needed
  - Detect and repair duplicate transactions

In an Open Environment: 2

- Sophisticated means to maintain shared state, e.g., conversations
  - Coherence of local states
  - Not immediate consistency, as traditional databases promise
  - Eventual "consistency" (howsoever understood)

Challenges

- Information system interoperation
- Business operations
- Exception handling
- Distributed decision-making
- Personalization
- Service selection (location and assessment)

Information System Interoperation: Supply Chains

The flow of materiel and goods from manufacturers and integrators to customers

- Flow of information among these parties
- Domain independent, e.g., Universal Business Language
  - Delivery requirements
  - Prices
- Domain dependent
  - Product specifications

Business Operations

Modeling and optimization

- Typical emphasis on internal operations
  - Inventory management
  - Logistics: how to optimize and monitor flow of materiel
  - Billing and accounts receivable
  - Accounts payable
  - Customer support
- More interesting situations in cross-organizational settings
  - Rules of encounter: normative and economic mechanisms
  - Handling exceptions

Exception Conditions

Virtual enterprises to construct enterprises dynamically to provide more appropriate, packaged goods and services to common customers

- Requires the ability to
  - Construct teams
  - Enter into multiparty deals
  - Handle authorizations and commitments
  - Accommodate exceptions
- Real-world exceptions
- Compare with PL or OS exceptions

Distributed Decision-Making: Closed

Manufacturing control: manage the operations of factories

- Requires intelligent decisions to
  - Plan inflow and outflow
  - Schedule resources
  - Accommodate exceptions

Distributed Decision-Making: Open

Automated markets as for energy distribution

- Requires abilities to
  - Set prices, place or decide on others' bids
  - Accommodate risks
- Economic mechanism (e.g., pricing, penalties) for rational resource allocation

Personalization

Consumer dealings to make the shopping experience a pleasant one for the customer

- Requires
  - Learning and remembering the customer's preferences
  - Offering guidance to the customer (best if unintrusive)
  - Acting on behalf of the user without violating their autonomy

Service Selection

Accommodating and benefiting from dynamism

What are some bases for selecting the parties to deal with?

- Specify services precisely and search for them
  - How do you know they do what you think they do (ambiguity)?
  - How do you know they do what they say (trust)?
- Recommendations to help customers find relevant and high quality services
  - How do you obtain and aggregate evaluations?