DSE 203

DAY 1: INFORMATION HETEROGENEITY

Information Heterogeneity – a typology

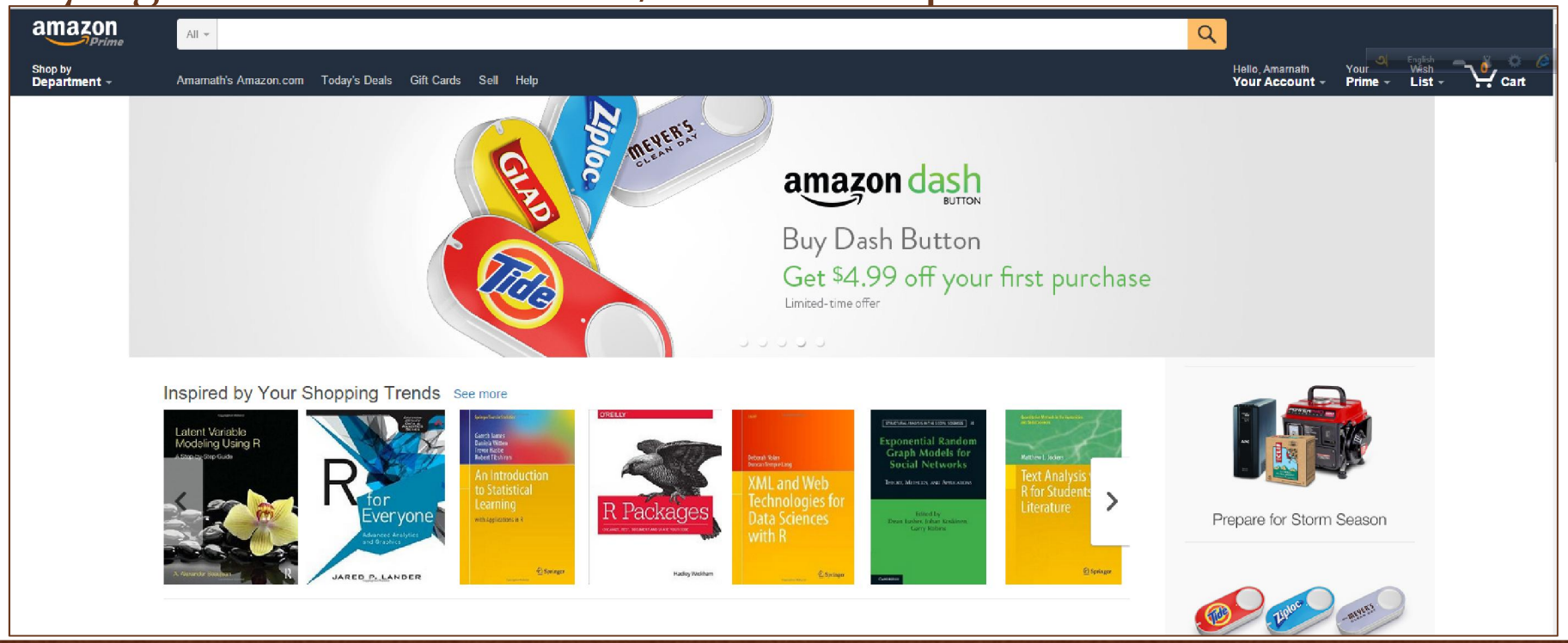
- Heterogeneity
  - System Level
    - Hardware/Software Level
    - Interface Level
  - Structural
    - Data Model Related
    - Schema Related
  - Semantic
    - Identity Conflicts
    - Naming Conflicts
    - Value Conflicts

Heterogeneity in Hardware/System Software

- Hardware differences
  - Mobile phone vs. laptop vs. servers
  - Not every platform can do every query equally effectively
    - “Find a McDonalds near me” while driving a car
    - “Outer Join policy holders with bank customers”
- Different protocols, binary file formats, …
  - Order information stored in text files: line ending differs between Mac/Window/Linux, character encoding
- Different access control mechanism
  - FTP-access to files: public, ssh authentication, ..

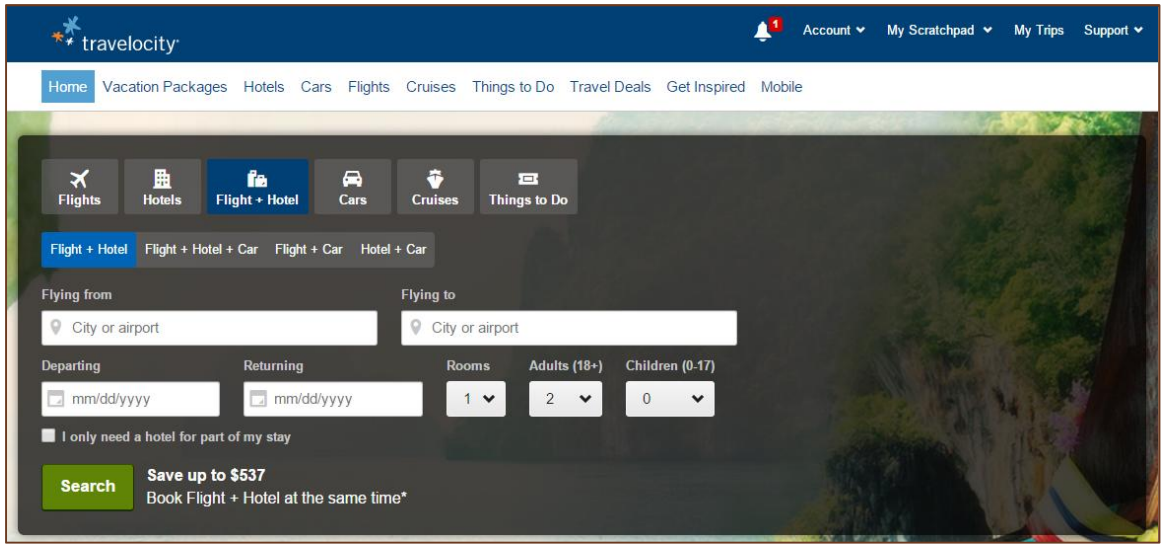
Heterogeneity in Query Interfaces

- Two systems might use the same data model and yet may significantly differ in the way they allow access to their data
- Querying Amazon – what can/can't we express?

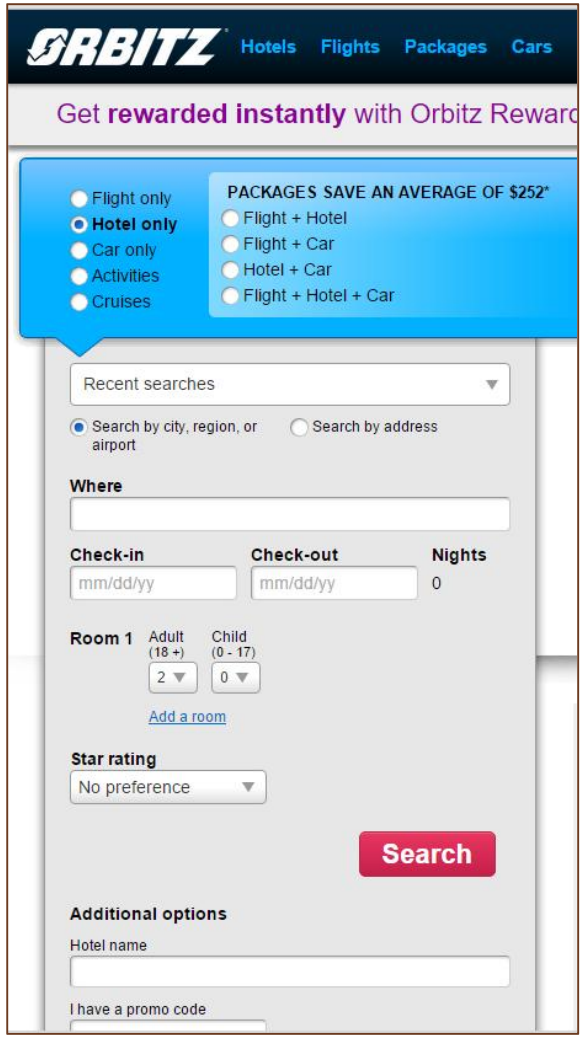


Heterogeneity in Query Interfaces

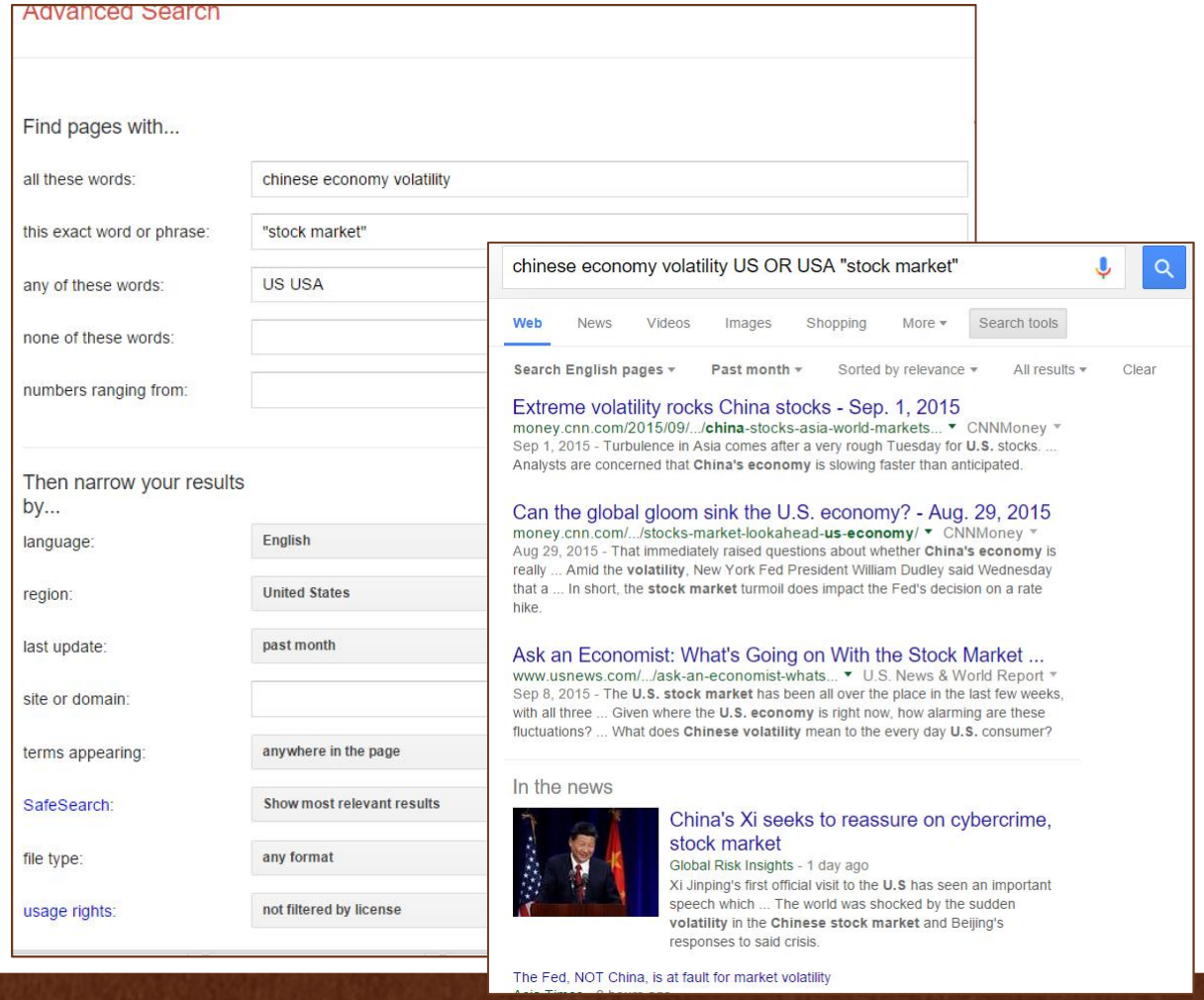
- Travelocity and Orbitz
  - Is there a difference in their query capabilities?



- Querying with web forms – what are the benefits and limitations?
  - Relations with binding patterns



Heterogeneity in Query Interfaces



- Querying search engines
  - Keywords + partly structured search
- What can we express with search engines that we cannot with standard databases?

Heterogeneity in Query Interfaces

All services are subject to change at any time.

The services include the ability to:

Retrieve a federation summary, e.g., http://nif-services.neuinfo.org/servicesv1/v1/summary?q=*

Retrieve data records from a NIF federation source for a search, e.g., http://nif-services.neuinfo.org/servicesv1/v1/federation/data/nif-0000-00007-1?q=purkinje

Retrieve registry data records from NIF, e.g., http://nif-services.neuinfo.org/servicesv1/v1/federation/data/nlx_144509-1?q=miame

Retrieve a complete search summary, e.g., http://nif-services.neuinfo.org/servicesv1/v1/federation/search?q=cortex

Retrieve NIF auto-complete suggestions, e.g., http://nif-services.neuinfo.org/servicesv1/v1/vocabulary?prefix=hippo

Use the NIF annotator for arbitrary text, e.g., http://nif-services.neuinfo.org/servicesv1/v1/annotate?content=The%20cerebellum%20is%20a%20wonderful%20thing

http://www.neuinfo.org/developers/nif_web_services.shtm

- Web services – function calls made over the web
- What schema are we querying against?
  - Every web service call has a response schema
    - Can be thought of as a ***view*** over an unknown relation

Heterogeneity in Query Interfaces

- Interface Heterogeneity – Expressiveness
  - Keyword-search vs. query language
- Query Language
  - Predicates: equality (=), inequality (<, !=)
  - Logical connectives: conjunctive (AND)
  - disjunctive (OR), negation
  - Complex operations: aggregation, quantification
  - Limitations: user's knowledge of the schema, predicates, fixed queries with parameters, …

Heterogeneity in Query Interfaces

- Impacts on the integration system
- Unknown domain semantics
- Bounded Parameters
  - Not all attributes are available for query
  - The effective domain of an attribute can be restricted
  - Not all operations are available for an attribute
- Consequence
  - A reasonable query may have null result
  - An integration system may have to formulate multiple queries
    - "Find all children's books for $10 or less"
  - An integration system has to evaluate part of the query
    - "What's the name and price of Avi Silberscatz's latest book on Operating Systems?"

Structural Heterogeneity

- Data model
  - Different structure
  - Different semantics and expressiveness
- Schema
  - Integrity constraints, keys
  - Schema elements
    - Differently modeled attribute and relations
- Structure
  - Flat relational vs. nested relational
  - Deep vs. shallow trees in XML

Relational Conflicts

- Naming and Schema conflicts
  - Person(Id, name, gender, birthday)
  - Person(Id, firstname, lastname, male, female)
  - Manager(Id, name, gender, age)

what kind of conflict is this?

- Conflicting integrity constraints
  - Person(Id, name, gender, birthday) – gender is not null, today().year-birthday.year > 18
  - Person(Id, name, gender='female', birthday)

Relational Conflicts

- Attribute conflicts
  - Person(SSN:integer, name:varchar(128), gender:string, birthday:datetime)
  - Person(SSN:varchar(9), name:varchar(64), gender:{‘M’, ‘F’, ‘unwilling to reveal’, default=‘unknown’}, birthdate:integer) – counting in days from 1/1/1900.
  - Person(SSN:string, name:string, gender:{0, 1,-99}, DOB:string(format:’dd-mm-yy’))

Structural Mismatch – relations, attributes, values

LabResults(orderID, date, PatientID, Test1,Test2, Test3,….)

LabResults(orderID, date, PatientID, TestID, TestValue)

Test1Results(orderID, date, PatientID, TestValue), Test2Results(orderID, date, PatientID, TestValue), …

LabResults(orderID, date, PatientID, Tests(TestID, TestValue))

- User's query
  - Find the value for Test#3, Test#4 for PatientID='12345' for date='09/03/2015'
  - Select Tests from LabResults
    where PatientID='12345' and date=='09/03/2015' and
    Tests.TestID = '3' or Tests.TestID = '4'

Which model is the target schema using?

Handling Schema Heterogeneity

- The integration system needs to provide
  - Unified access to multiple schemas
  - An integrated schema over existing schema
- Schema level actions
  - Schema mapping, model management operators, schema languages
- Data level actions
  - Data transformation (ETL), data exchange, warehousing
- These are topics we will cover over this term

Semantic Conflicts

- The identity problem
  - Also called record linking, deduplication, entity resolution

Hospital A's record:

PID	SSN	FName	MI	LName	DOB	Address	Allergies
15883	555-43-2991	Florence	E	Schwartz	06/21/67	6345 Tony Drive, San Diego, CA 92127	Peanut, Cat fur, Pine pollen

Hospital B's record:

PID	SSN	FName	MI	LName	DOB	Address	Allergies
231834	653-86-9950	Flora	E	Schwartz-Jones	06/21/67	12290 Carmel Pointe, San Diego, CA 92130	Peanut, Cat fur, Pine pollen

Do these records belong to the same person?

Value Conflicts – a kind of Semantic Conflict

- Non-ontological Conflicts
  - Objects representing the same entities have conflicting values for semantically equivalent attributes
    - Is the name of the company Google or Alphabet? IBM or International Business Machines?
      - In many cases other attributes like Date should be used to resolve value conflicts
    - Measurement related values may conflict due to choice of (often unmentioned) units
- There must be a way to identify that these objects are represent the same entity first!
- Resolving such conflicts require Data Fusion
  - Pick value from conflicting values
  - Numerical methods: e.g., average
  - Preferred value
  - Coarsification of granularity – e.g., latitude longitude

Ontological Conflicts – a kind of Semantic Conflict

- Same attribute, different domains
  - Human vs. homo sapiens
- Same attribute, different levels of granularity
  - Subclass-based granularity
    - Rodents vs. mice
  - Partonomy-based granularity
    - Distal phalanges vs. hand
- Different attributes, different levels granularity
  - Location
    - Named location vs. latitude-longitude

Ontological Conflicts – a kind of Semantic Conflict

- Implicit vs. Explicit constraints

PID	Image Type	Image SubType	View	Region Imaged	Visible Organs	Findings
15883	T1	Spin Echo	Sagittal	Lumber Spine	thoracic spine, spinal cord and sacrum	No visible abnormality

PID	Image Type	Image SubType	View	Region Imaged	Visible Organs	Findings
15883	MRI	Spin Echo	Sagittal	Lumber Spine	thoracic spine, spinal cord and sacrum	No visible abnormality

- Find all MRI images where the region viewed is Lumber Spine

Ontological Conflicts – a kind of Semantic Conflict

Ontological concepts

– Relationships between concepts

- **A = B** - Equivalence
- **A ⊆ B** - Inclusion
- **A ∩ B** - Overlap
- **A ≠ B** - Disjunction

Handling Ontological Conflicts

- The integration system needs to provide
  - A way to specify which schema elements conform to which ontologies
  - A way to specify ontological relationships as part of the query
  - A way to perform query evaluation using ontological relationships
- Schema level actions
  - Schema mapping to ontologies
- Data level actions
  - Data mappings to ontologies