Perspectives on Data

Tradeoffs and considerations in data modeling

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Types of Data

Tabular Data: Tables, Spreadsheets, DataFrames

Semi-Structured Data: JSON, XML

Unstructured Data: Text, Video, Images, Raw Sensor Data

Tabular Data

A rectangular data structure where rows correspond to observations and each column corresponds to properties (attributes) of the observation.

Customers

CustomerId	FirstName	LastName	DateCreated	Cli
1	Homer	Simpson	13/06/2014 3:33:37 PM	
2	Peter	Griffin	13/06/2014 9:09:56 PM	
3	Stewie	Griffin	13/06/2014 9:16:07 PM	
4	Brian	Griffin	13/06/2014 9:16:36 PM	
5	Cosmo	Kramer	13/06/2014 9:16:41 PM	
6	Philip	Fry	13/06/2014 9:17:02 PM	
7	Amy	Wong	13/06/2014 9:22:05 PM	
8	Hubert J.	Farnsworth	13/06/2014 9:22:19 PM	
9	Marge	Simpson	13/06/2014 9:22:37 PM	
10	Bender	Rodríguez	13/06/2014 9:22:52 PM	
11	Turanga	Leela	13/06/2014 9:23:37 PM	
(New)			15/06/2014 9:00:01 PM	

Tabular Data

Characteristic 1. **Named Attributes**

- The columns names define all of the relevant attributes for each observation.

- Values are accessed by name.

- Every row has the same set of attributes (if data are missing, value is explicitly NULL)

Customers

CustomerId	FirstName	LastName	DateCreated	Cli
1	Homer	Simpson	13/06/2014 3:33:37 PM	
2	Peter	Griffin	13/06/2014 9:09:56 PM	

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Tabular Data

Characteristic 2. **Atomic Values**

- Each cell (a row, column pair) is generally considered to be an atomic value---i.e., it is not readily divisible--such as, an integer, a date, a string.

- Each column has a defined data type consistent across all rows.

Customers

CustomerId	FirstName	LastName	DateCreated	Cli
1	Homer	Simpson	13/06/2014 3:33:37 PM	
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Schema

An abstract definition of a tabular dataset consisting of a set of named attributes and their corresponding data types.

Car(Make: String, Model: String, Year: Int)

Person(First: String, Last: String, SSN: String)

Grade(SID: String, Class: String, Score: Float)

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Data Model

Key advantage is that you can separate how users program against the data from how the data are actually stored.

```
df['name'] = df['name'].lower()
```

Has to be a string

Logical data model: describes the semantics of the data, as represented by the particular data analysis technology.

Physical data model: Describes the physical means by which data are stored in terms of bits and organization.

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Semi-Structured Data

A data structure where each row has a variable set of attributes the values are possibly not atomic.

```
{'name': ‘Car1’, 'features': [‘BackupCamera’, ‘CruiseControl’]}
{'name': ‘Car2’, 'features': [‘BackupCamera', ‘ParkingAssist’,
‘CruiseControl’]}
```

```
- <Parts>
  - <Part>
      <Id>4478</Id>
      <Part_Name>1000 Ohm Resistor</Part_Name>
      <Total_Available>25000</Total_Available>
      <Price>0.01</Price>
    </Part>
  - <Part>
      <Id>3328</Id>
      <Part_Name>15000 Ohm Resistor</Part_Name>
      <Total_Available>75000</Total_Available>
      <Price>0.02</Price>
    </Part>
  - <Part>
      <Id>4725</Id>
      <Part_Name>555 Timer IC</Part_Name>
      <Total_Available>1500</Total_Available>
      <Price>0.25</Price>
    </Part>
  </Parts>
```

Semi-Structured Data

Characteristic 1. **Named Attributes**

- Attributes are still named!

- But each row may have a different set of named attributes.

```
- <Parts>
  - <Part>
      <Id>4478</Id>
      <Part_Name>1000 Ohm Resistor</Part_Name>
      <Total_Available>25000</Total_Available>
      <Price>0.01</Price>
    </Part>
  - <Part>
      <Id>3328</Id>
      <Part_Name>15000 Ohm Resistor</Part_Name>
      <Total_Available>75000</Total_Available>
      <Price>0.02</Price>
    </Part>
  - <Part>
      <Id>4725</Id>
      <Part_Name>555 Timer IC</Part_Name>
      <Total_Available>1500</Total_Available>
      <Price>0.25</Price>
    </Part>
</Parts>
```

Semi-Structured Data

Characteristic 2. **Nested Values**

- Values are not atomic and can be nested data structures.
- Data type is generally inferred on the fly.

```
- <Parts>
- <Part>
    <Id>4478</Id>
    <Part_Name>1000 Ohm Resistor</Part_Name>
    <Total_Available>25000</Total_Available>
    <Price>0.01</Price>
  </Part>
- <Part>
    <Id>3328</Id>
    <Part_Name>15000 Ohm Resistor</Part_Name>
    <Total_Available>75000</Total_Available>
    <Price>0.02</Price>
  </Part>
- <Part>
    <Id>4725</Id>
    <Part_Name>555 Timer IC</Part_Name>
    <Total_Available>1500</Total_Available>
    <Price>0.25</Price>
  </Part>
</Parts>
```

Semi-Structured Schema

Can think of each row as defining its own schema and that definition is stored with each row.

```
- <Parts>
  - <Part>
      <Id>4478</Id>
      <Part_Name>1000 Ohm Resistor</Part_Name>
      <Total_Available>25000</Total_Available>
      <Price>0.01</Price>
    </Part>
  - <Part>
      <Id>3328</Id>
      <Part_Name>15000 Ohm Resistor</Part_Name>
      <Total_Available>75000</Total_Available>
      <Price>0.02</Price>
    </Part>
  - <Part>
      <Id>4725</Id>
      <Part_Name>555 Timer IC</Part_Name>
      <Total_Available>1500</Total_Available>
      <Price>0.25</Price>
    </Part>
  </Parts>
```

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Unstructured Data

Everything else!

Text files and documents	Server, website and application logs	Sensor data	Images
Video files	Audio files	Emails	Social media data

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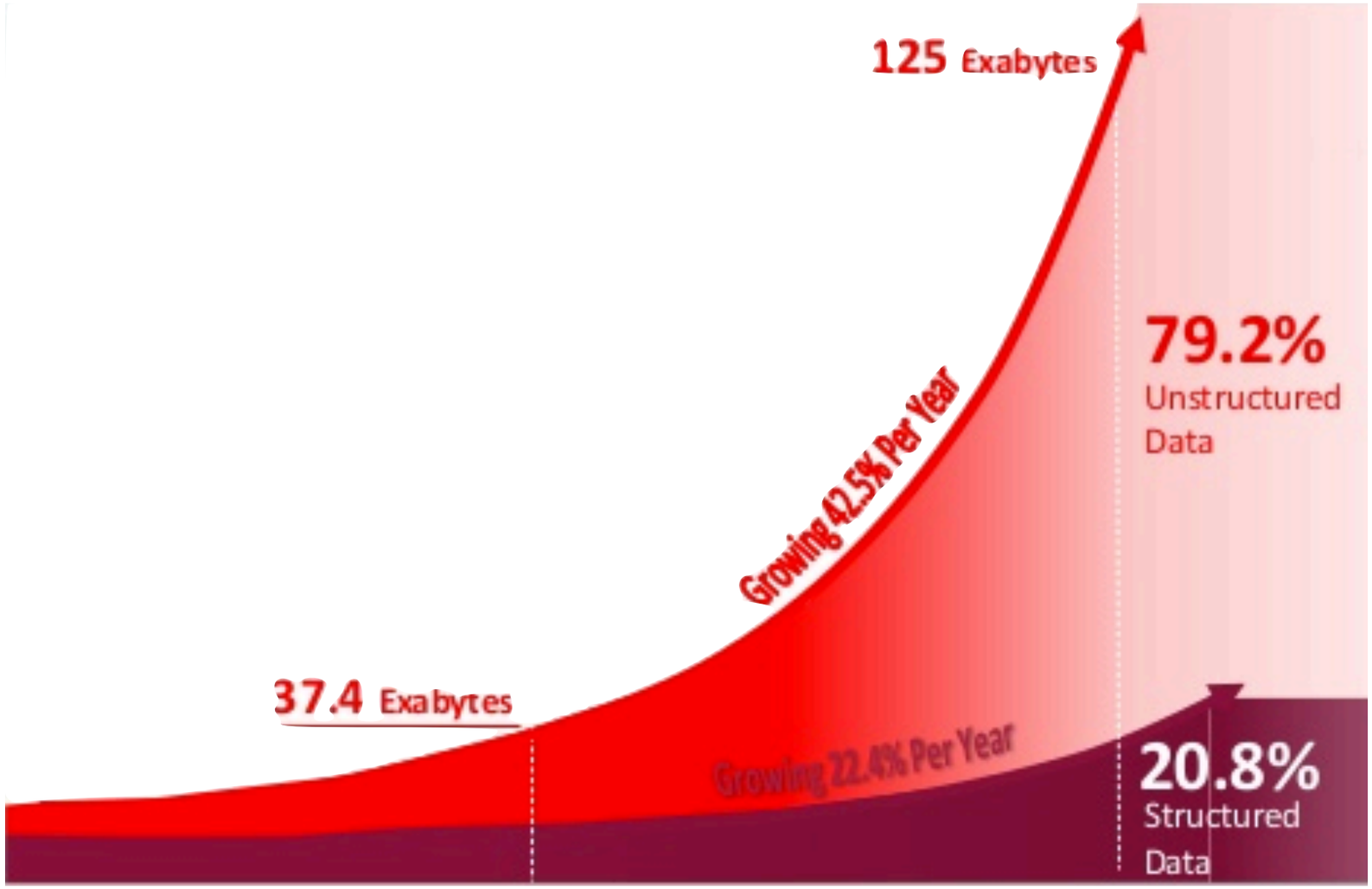
Unstructured Data



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Tradeoffs

Most organizations have a mix of different types of data!

Tabular Data: Tables, Spreadsheets, DataFrames

+ Simplified programming model (Pandas, SQL, Excel)
+ Efficient and scalable

- Inflexible (need to define a schema up front)
- Hard to migrate data into other systems

Semi-Structured Data: JSON, XML

+ Very flexible (on-the-fly schema design)
+ Portable (readable by all major programming languages)

- Hard to debug code with complex failure modes
- Extra data and extra code

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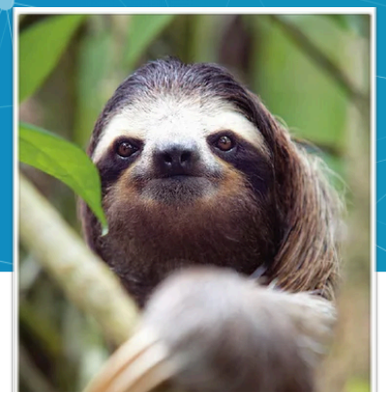
Example



Add profile section | More...

Sammy Sloth

Assistant head sloth at the Lincoln Park Zoo

Chicago

Chicago, Illinois · 187 connections · Contact info

Good at climbing and eating fruits and vegetables. Looking for a new part-time job with flexible hours and great benefits.

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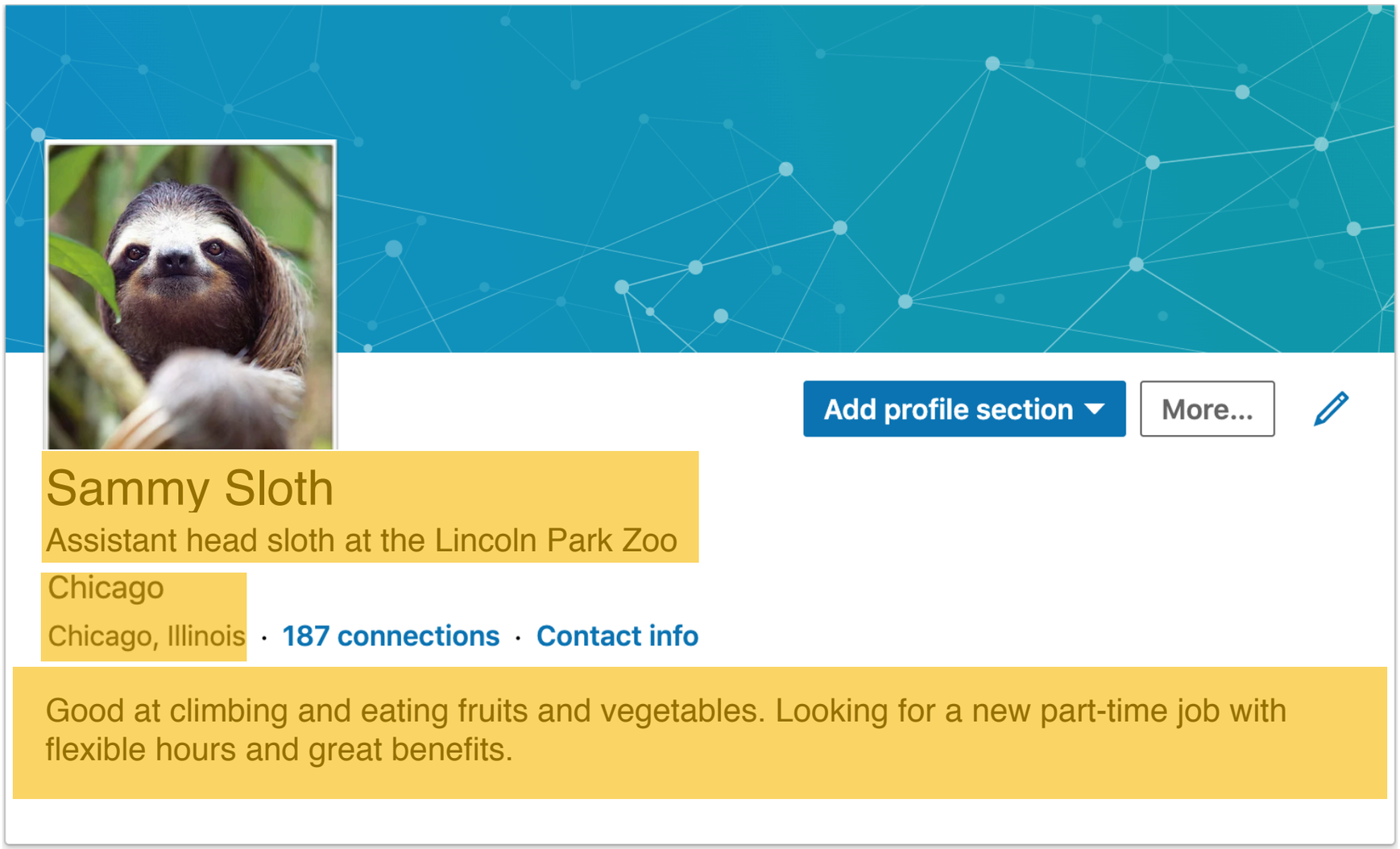
Example



Semi-Structured Data

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Example

```
{‘name’: ‘Sammy Sloth’,
 ‘location_city’: ‘Chicago’,
 ‘location_state’: ‘Illinois’,
 ‘position’: ‘Assistant head sloth at the Lincoln Park Zoo’,
 ‘looking_for’: ‘Good at climbing and eating fruits and
vegetables. Looking for a new part-time job with flexible
hours and great benefits.’
}
```

+ Flexible
+ Redesign of the website doesn’t need a data change
+ Portable

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Example

Count the number of climbers per city

```
cities = {}

for a in Animals:
   obj = json.loads(a)
   city = obj[‘location_city’]
   is_climber = obj[‘looking_for’].contains(‘climber’)

   if city not in cities:
      cities[city] = 0

   cities[city] += (is_climber)
```

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Example

Count the number of climbers per **state**

```
states = {}

for a in Animals:
   obj = json.loads(a)
   state = obj[‘location_state’]
   is_climber = obj[‘looking_for’].contains(‘climber’)

   if state not in states:
      states[state] = 0

   states[state] += (is_climber)
```

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Example

Extracting structured tables from semi-structured or unstructured data simplifies analysis later on

```
{‘name’: ‘Sammy Sloth’,
 ‘location_city’: ‘Chicago’,
 ‘location_state’: ‘Illinois’,
 ‘position’: ‘Assistant head sloth at the Lincoln Park Zoo’,

 ‘looking_for’: ‘Good at climbing and eating fruits and
vegetables. Looking for a new part-time job with flexible hours
and great benefits.’
}
```

Talent(Name: String, City: String, State:String, Climbing: Boolean)

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Example

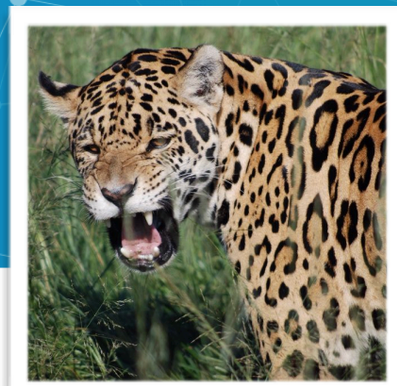
Count the number of climbers per city

Talent(Name: String, City: String, State:String, Climbing: Boolean)

```
df.group_by('city').sum('climbing')
df.group_by('state').sum('climbing')
```

+ Cost of structuring data amortizes over all the analyses you want to do

Example



Jaime Jaguar

Jaguar at the Lincoln Park Zoo
Chicago

Chicago, Illinois · 187 connections · Contact info

Just a good ole' big cat who hates climbers and looking for a good time.

Add profile section | More...

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Example

Format conversions often lose or misrepresent data

‘looking_for’: ‘Just a good ole’ big cat who hates **climbers** and looking for a good time.’

Talent(Name: String, City: String, State:String, **Climbing: Boolean**)

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Paradox of Structured Data

Always certain, seldom right

- Query languages (like SQL) are built on the principles of formal logic
- A *database* holds facts and allows users to make principled inferences from these facts

Paradox of Structured Data

- Mary is a citizen of France
- Jenny is a citizen of France
- All French citizens wear hats

People

Name	Citizenship
Mary	France
Jenny	France

Countries

Citizenship	Wears
France	hats

What is Mary's citizenship?

```
SELECT Citizenship
FROM People
WHERE Name='Mary';
```

```
people[people[‘name’]=‘Mary’]
```

Do both Mary and Jenny wear hats?

```
SELECT Name, Wears
FROM People, Countries
WHERE People.Citizenship =
      Countries.Citizenship;
```

```
people.merge(countries)
```

Paradox of Structured Data

Does Peter Wear A Hat? →

```
SELECT Name, Wears
FROM People, Countries
WHERE People.Citizenship =
      Countries.Citizenship AND
      People = 'Peter';
```

```
peter = people[people['name']='Peter']
peter.merge(countries)
```

Closed World Assumption: Everything not currently known to be true, is false

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Example

Up-to the developer to understand and account for uncertainty

‘looking_for’: ‘Just a good ole’ big cat who hates **climbers** and looking for a good time.’

Talent(Name: String, City: String, State:String, **Climbing: Boolean**)