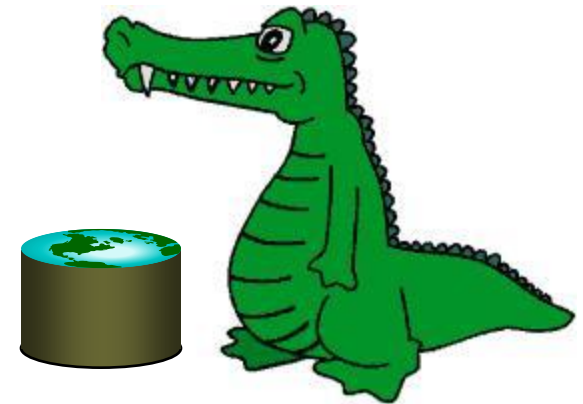


# Introduction to Data Science



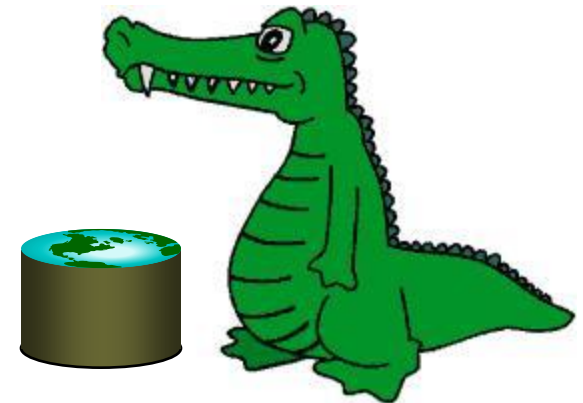
# Data Wrangling

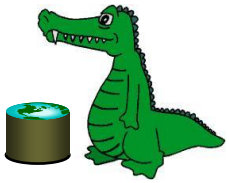
Data Types

Data Sources

Data Models

Data Preparation



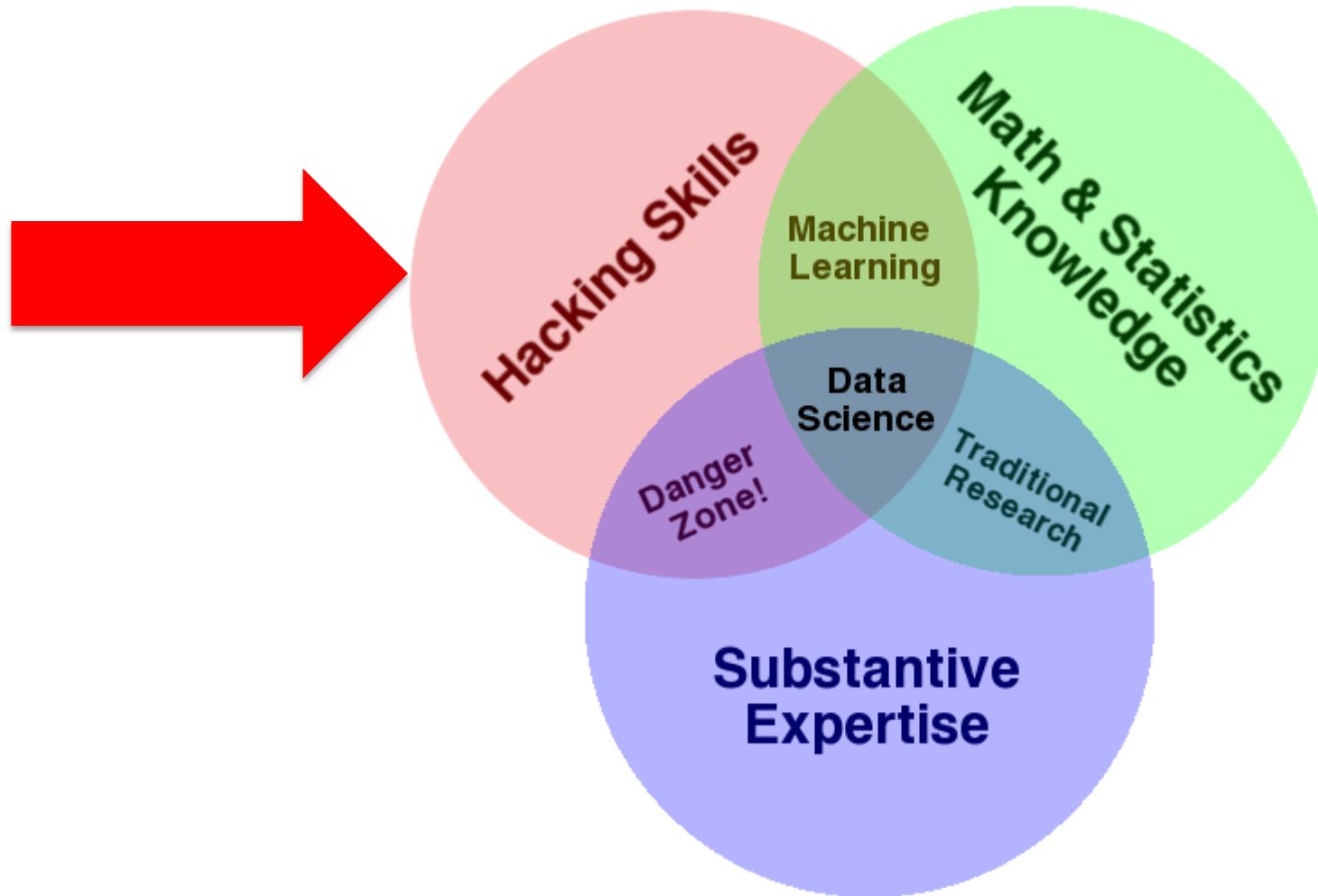


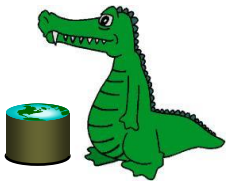
# Outline

- Big Picture
- Data Types and Sources
- Data Models
- Data Preparation

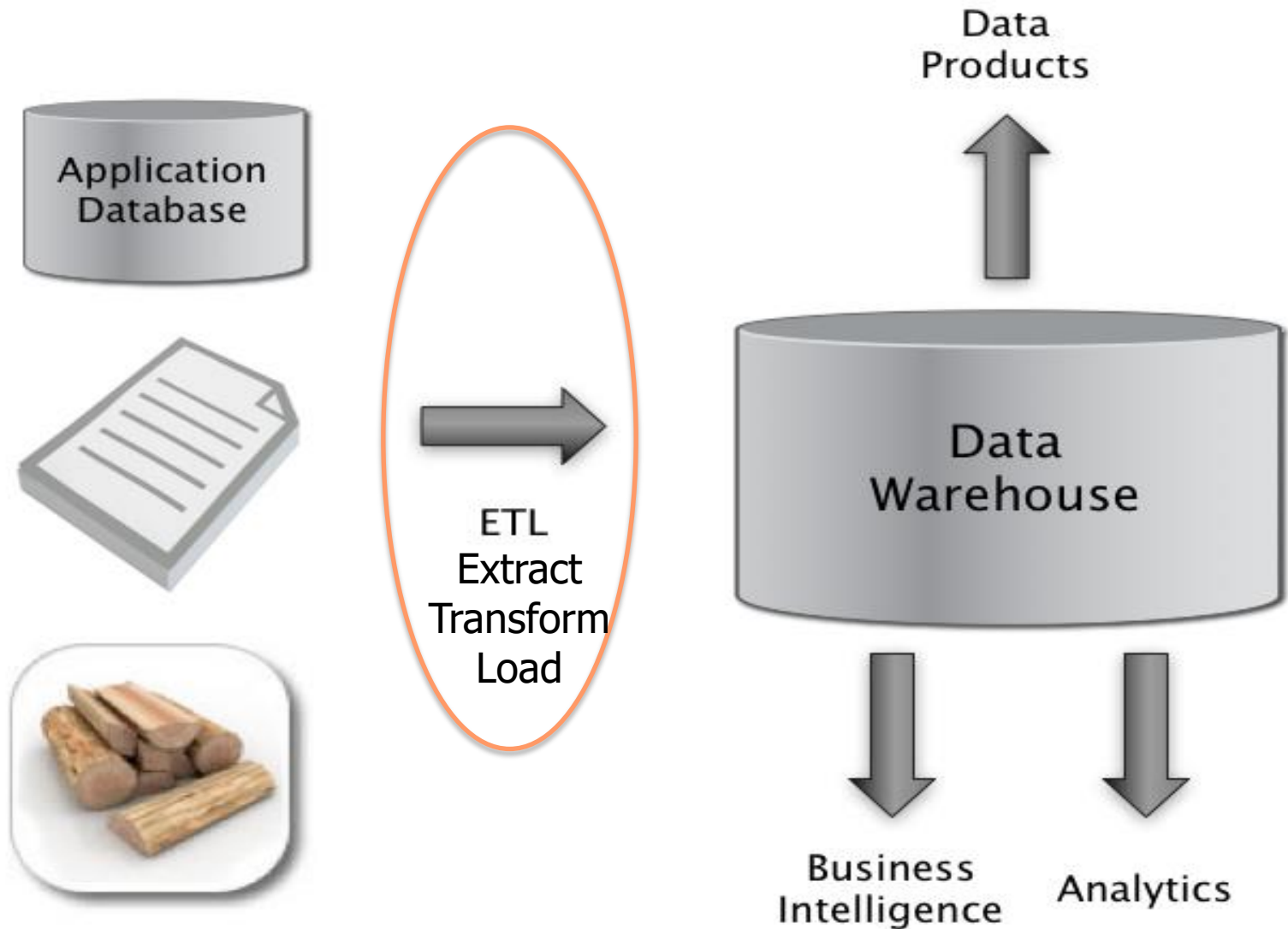


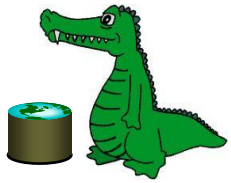
# Data Science – One Definition





# The Big Picture





# What are your...

- Data Sources?
- ETL Process/Workflow and tools?
- Data Warehouse?
- Business Intelligence and Analytics?



# The Businessperson

- Data Sources
  - Web pages
  - Excel
- ETL
  - Copy and paste
- Data Warehouse
  - Excel
- Business Intelligence and Analytics
  - Excel functions
  - Excel charts



# The Programmer

- Data Sources
  - Web scraping, web services API
  - Excel spreadsheet exported as CSV
  - Database queries
- ETL
  - wget, curl, BeautifulSoup, lxml
- Data Warehouse
  - Flat files
- Business Intelligence and Analytics
  - Numpy, Matplotlib, R, Matlab





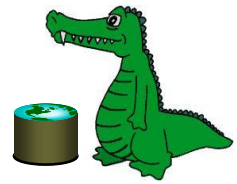
# The Enterprise

- Data Sources
  - Application databases
  - Intranet files
  - Application server log files
- ETL
  - Informatica, IBM DataStage, Ab Initio, Talend
- Data Warehouse
  - Teradata, Oracle, IBM DB2, Microsoft SQL Server
- Business Intelligence and Analytics
  - Business Objects, Cognos, Microstrategy
  - SAS, SPSS, R



# The Web Company

- Data Sources
  - Application databases
  - Logs from the services tier
  - Web crawl data
- ETL
  - Flume, Sqoop, Pig, Crunch, Oozie
- Data Warehouse
  - Hadoop/Hive, Spark/Shark
- Business Intelligence and Analytics
  - Custom dashboards: Argus, BirdBrain
  - R



# Outline

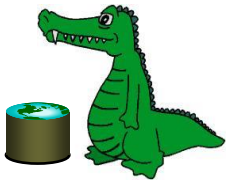
- Big Picture
- Data Types and Sources
- Data Models
- Data Preparation



# Data Sources at Web Companies

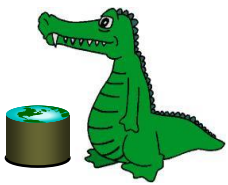
- Examples from Facebook
  - Application databases
  - Web server logs
  - Event logs
  - API server logs
  - Ad server logs
  - Search server logs
  - Advertisement landing page content
  - Wikipedia (and other knowledge bases)
  - Images and video

From structured to unstructured



# Tabular Data

- What is a table?
  - A **table** is a collection of **rows** and **columns**
  - Each row has an **index (a.k.a., key)**
  - Each column has a **name**
  - A **cell** is specified by an (index, name) pair
  - A cell may or may not have a **value**



# Tabular Data

- Fortune 500

	A	B	C	D	E	F	G	H	I
1	rank	company	cik	ticker	sic	state_location	state_of_incorporation	revenues	profits
2	1	Wal-Mart Stores	104169	WMT	5331	AR	DE	421849	16389
3	2	Exxon Mobil	34088	XOM	2911	TX	NJ	354674	30460
4	3	Chevron	93410	CVX	2911	CA	DE	196337	19024
5	4	ConocoPhillips	1163165	COP	2911	TX	DE	184966	11358
6	5	Fannie Mae	310522	FNM	6111	DC	DC	153825	-14014
7	6	General Electric	40545	GE	3600	CT	NY	151628	11644
8	7	Berkshire Hathaway	1067983	BRKA	6331	NE	DE	136185	12967
9	8	General Motors	1467858	GM	3711	MI	MI	135592	6172
10	9	Bank of America Corp.	70858	BAC	6021	NC	DE	134194	-2238
11	10	Ford Motor	37996	F	3711	MI	DE	128954	6561
12	11	Hewlett-Packard	47217	HPQ	3570	CA	DE	126033	8761
13	12	AT&T	732717	T	4813	TX	DE	124629	19864
14	13	J.P. Morgan Chase & Co.	19617	JPM	6021	NY	DE	115475	17370
15	14	Citigroup	831001	C	6021	NY	DE	111055	10602
16	15	McKesson	927653	MCK	5122	CA	DE	108702	1263
17	16	Verizon Communications	732712	VZ	4813	NY	DE	106565	2549
18	17	American International Group	5272	AIG	6331	NY	DE	104417	7786
19	18	International Business Machines	51143	IBM	3570	NY	NY	99870	14833
20	19	Cardinal Health	721371	CAH	5122	OH	OH	98601.9	642.2
21	20	Freddie Mac	37785	FMC	2800	PA	DE	98368	-14025



# Tabular Data

- Fortune 500

Fortune 500 with ticker and EDGAR ☆

File Edit View Insert Format Data Tools Help Last edit wa

Share...

New ▶

Open... %O

Rename...

Make a copy...

Import...

See revision history

Spreadsheet settings...

Download as ▶

Publish to the Web...

Email collaborators...

Email as attachment...

Print %P

10pt B Abc A A

	C	D	E
	cik	ticker	sic
	104169	WMT	5331
	34088	XOM	2911
	93410	CVX	2911
	1163165	COP	2911
	310522	FNM	6111
	40545	GE	3600
	1067983	BRKA	6331
	1467858	GM	3711
	70858	BAC	6021
	37996	F	3711

CSV (current sheet)

HTML (current sheet)

Text (current sheet)

Excel

OpenOffice

PDF...

20 Freddie Mac

21 CVS Caremark



# Tabular Data (csv)

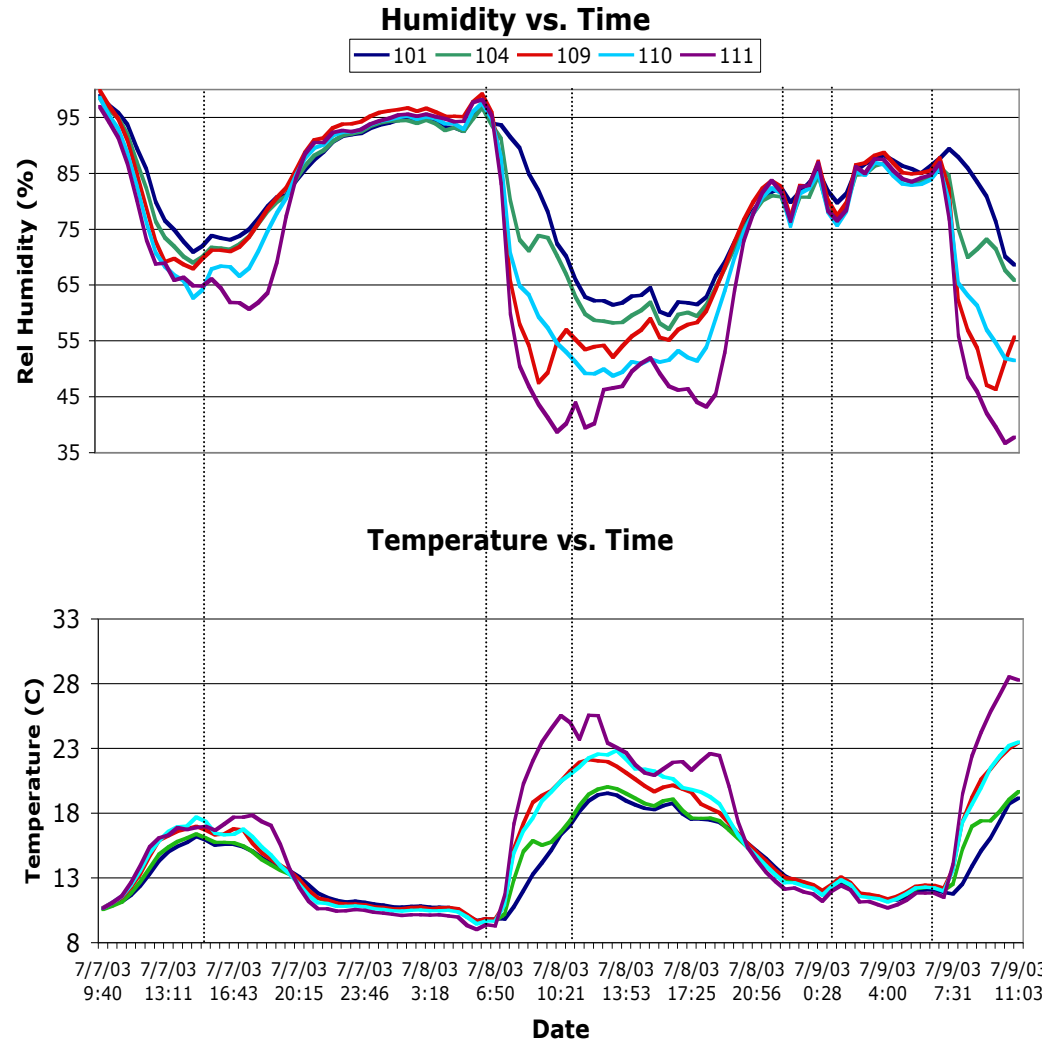
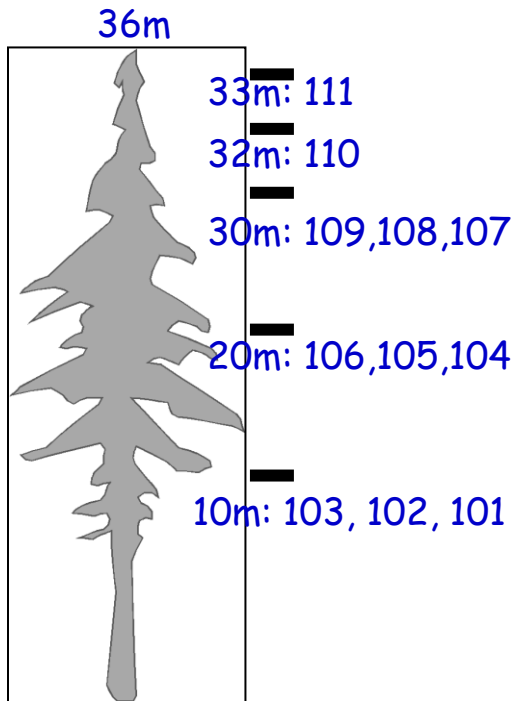
- Fortune 500

```
Fortune 500 with ticker and EDGAR – Plus Ticker and EDGAR.txt
rank,company,cik,ticker,sic,state_location,state_of_incorporation,revenues,profits
1,Wal-Mart Stores,104169,WMT,5331,AR,DE,421849,16389
2,Exxon Mobil,34088,XOM,2911,TX,NJ,354674,30460
3,Chevron,93410,CVX,2911,CA,DE,196337,19024
4,ConocoPhillips,1163165,COP,2911,TX,DE,184966,11358
5,Fannie Mae,310522,FNM,6111,DC,DC,153825,-14014
6,General Electric,40545,GE,3600,CT,NY,151628,11644
7,Berkshire Hathaway,1067983,BRKA,6331,NE,DE,136185,12967
8,General Motors,1467858,GM,3711,MI,MI,135592,6172
9,Bank of America Corp.,70858,BAC,6021,NC,DE,134194,-2238
10,Ford Motor,37996,F,3711,MI,DE,128954,6561
11,Hewlett-Packard,47217,HPQ,3570,CA,DE,126033,8761
12,AT&T,732717,T,4813,TX,DE,124629,19864
13,J.P. Morgan Chase & Co.,19617,JPM,6021,NY,DE,115475,17370
14,Citigroup,831001,C,6021,NY,DE,111055,10602
15,McKesson,927653,MCK,5122,CA,DE,108702,1263
16,Verizon Communications,732712,VZ,4813,NY,DE,106565,2549
17,American International Group,5272,AIG,6331,NY,DE,104417,7786
18,International Business Machines,51143,IBM,3570,NY,NY,99870,14833
19,Cardinal Health,721371,CAH,5122,OH,OH,98601.9,642.2
20,Freddie Mac,37785,FMC,2800,PA,DE,98368,-14025
21,CVS Caremark,64803,CVS,5912,RI,DE,96413,3427
22,UnitedHealth Group,731766,UNH,6324,MN,MN,94155,4634
23,Wells Fargo,72971,WFC,6021,CA,DE,93249,12362
24,Valero Energy,1035002,VLO,2911,TX,DE,86034,324
25,Kroger,56873,KR,5411,OH,OH,82189.4,1116.3
26,Procter & Gamble,80424,PG,2840,OH,OH,79689,12736
27,AmerisourceBergen,1140059,ABC,5122,PA,DE,77954,636.7
28,Costco Wholesale,909832,COST,5331,WA,WA,77946,1303
29,Marathon Oil,101778,MRO,2911,TX,DE,68413,2568
30,Home Depot,354950,HD,5211,GA,DE,67997,3338
```





# Internet of Things: Example measurements



In the news: Erika: data collecting sensors are dropped by airplanes



# Tabular Data from Sensors

## Challenges

- May be many missing fields (a particular sensor may not produce all types of output).
- Device may go offline for a while.
- Device may be damaged (permanently or intermittently).
- Timestamps usually critical but may not be accurate.
- Other meta-data (location, device ID) may have errors.



# Log Files – Example Apache Web Log

Processes, usually daemons, create logs  
e.g., httpd, mysqld, syslogd

- 66.249.65.107 - - [08/Oct/2007:04:54:20 -0400] "GET /support.html HTTP/1.1" 200 11179 "-" "Mozilla/5.0 (compatible; Googlebot/2.1; +http://www.google.com/bot.html)"
- 111.111.111.111 - - [08/Oct/2007:11:17:55 -0400] "GET / HTTP/1.1" 200 10801 "http://www.google.com/search?q=log+analyzer&ie=utf-8&oe=utf-8&aq=t&rls=org.mozilla:en-US:official&client=firefox-a" "Mozilla/5.0 (Windows; U; Windows NT 5.2; en-US; rv:1.8.1.7) Gecko/20070914 Firefox/2.0.0.7"
- 111.111.111.111 - - [08/Oct/2007:11:17:55 -0400] "GET /style.css HTTP/1.1" 200 3225 ""<http://www.loganalyzer.net/>" "Mozilla/5.0 (Windows; U; Windows NT 5.2; en-US; rv:1.8.1.7) Gecko/20070914 Firefox/2.0.0.7"



# Syslog – A Standard for System Messages

- Developed by Eric Allman (at Berkeley) as part of the Sendmail project
- Standardized by the IETF in RFC 3164 and RFC 5424
- Listens on port 514 using UDP
- Puts data in `/var/log/messages` by default
- Enables rich analysis





# Syslog

```
dhcp-47-129:DataScienceF14> syslog -w 10
```

```
Feb  3 15:18:11 dhcp-47-129 Evernote[1140] <Warning>: -[EDAMAccounting read:]: unexpected
field ID 23 with type 8. Skipping.
Feb  3 15:18:11 dhcp-47-129 Evernote[1140] <Warning>: -[EDAMUser read:]: unexpected field ID
17 with type 12. Skipping.
Feb  3 15:18:11 dhcp-47-129 Evernote[1140] <Warning>: -[EDAMAuthenticationResult read:]:
unexpected field ID 6 with type 11. Skipping.
Feb  3 15:18:11 dhcp-47-129 Evernote[1140] <Warning>: -[EDAMAuthenticationResult read:]:
unexpected field ID 7 with type 11. Skipping.
Feb  3 15:18:11 dhcp-47-129 Evernote[1140] <Warning>: -[EDAMAccounting read:]: unexpected
field ID 19 with type 8. Skipping.
Feb  3 15:18:11 dhcp-47-129 Evernote[1140] <Warning>: -[EDAMAccounting read:]: unexpected
field ID 23 with type 8. Skipping.
Feb  3 15:18:11 dhcp-47-129 Evernote[1140] <Warning>: -[EDAMUser read:]: unexpected field ID
17 with type 12. Skipping.
Feb  3 15:18:11 dhcp-47-129 Evernote[1140] <Warning>: -[EDAMSyncState read:]: unexpected
field ID 5 with type 10. Skipping.
Feb  3 15:18:49 dhcp-47-129 com.apple.mtmtd[47] <Notice>: low priority thinning needed for
volume Macintosh HD (/) with 18.9 <= 20.0 pct free space
```

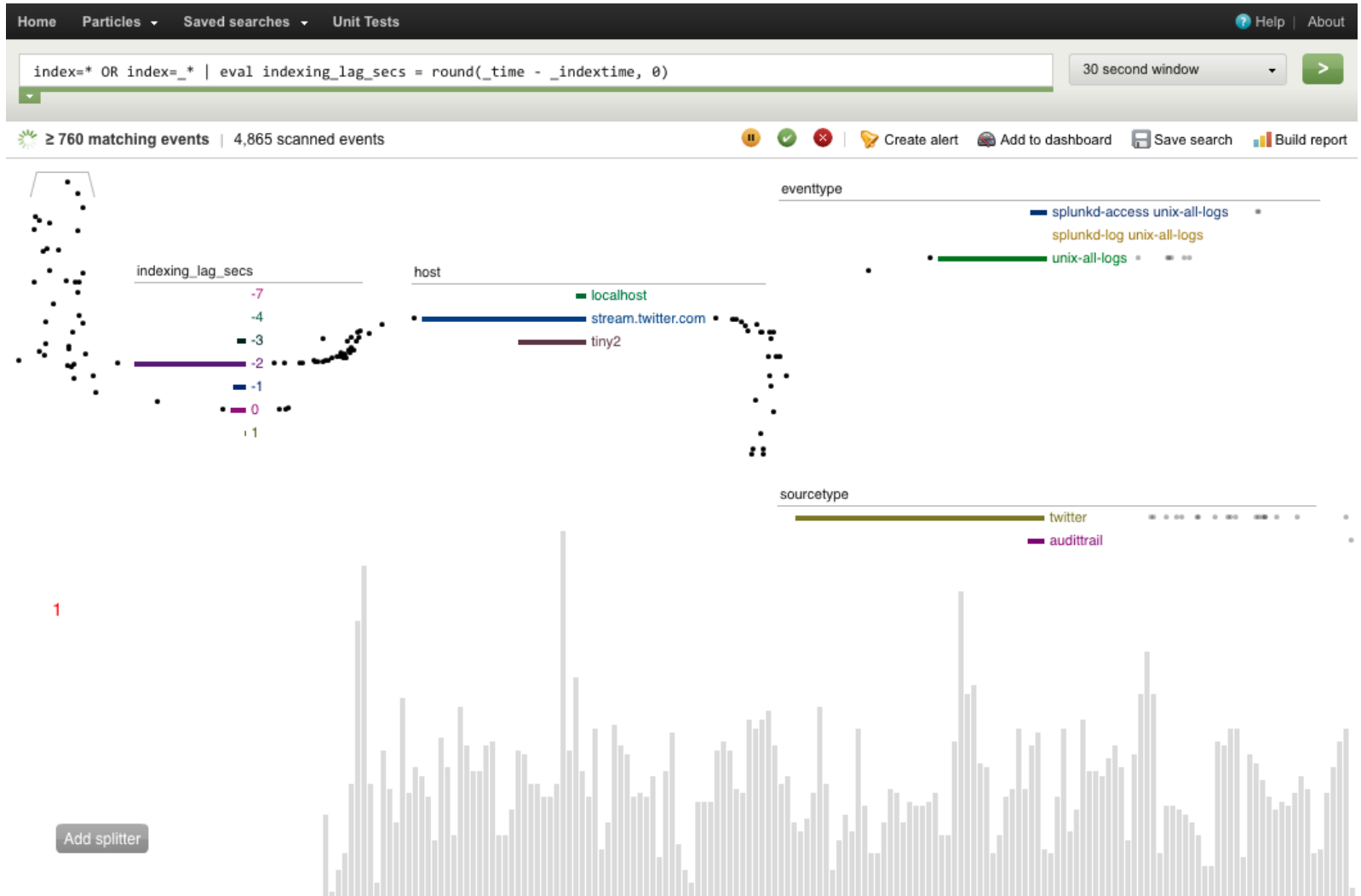


# "Splunking"

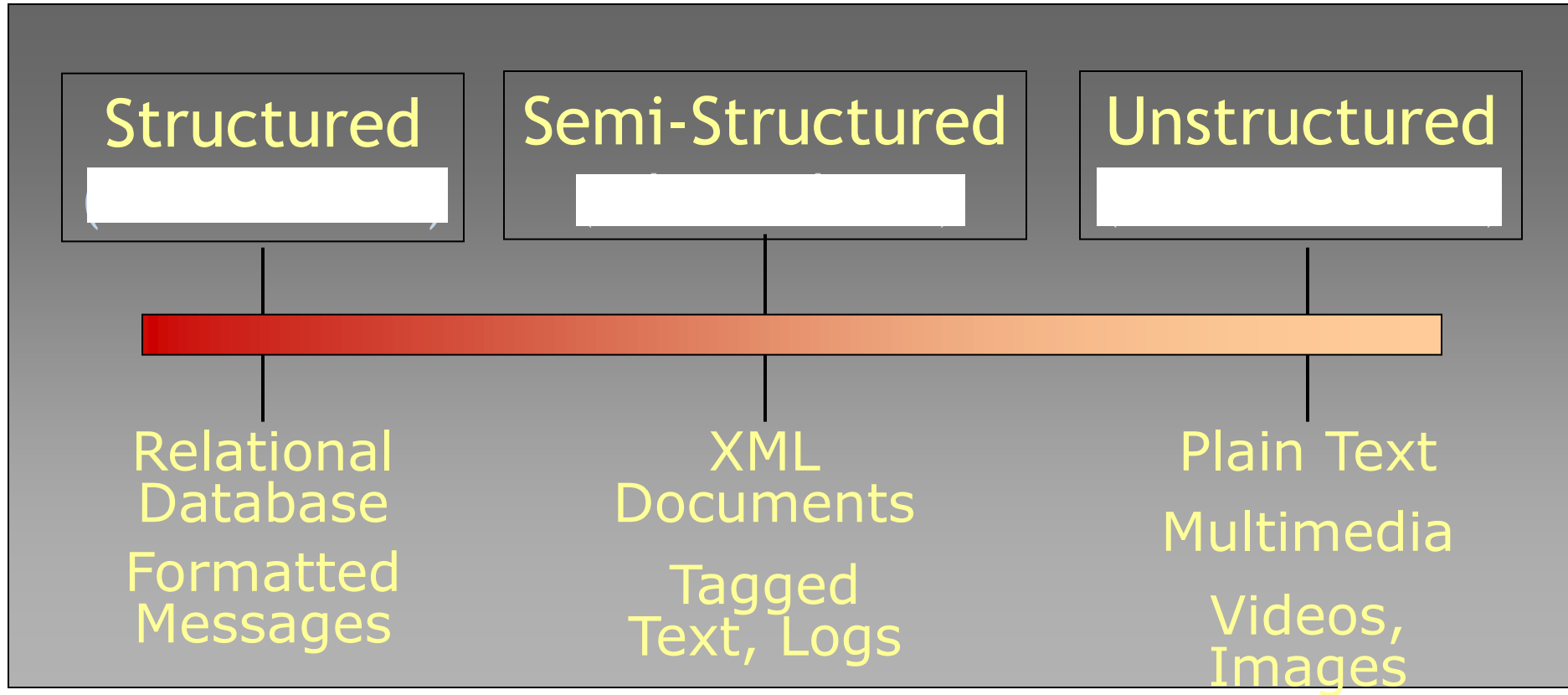
- Grab data from many machines
- Index it
- Check for unusual events:
  - Disk problems
  - Network congestion
  - Security attacks
- Monitor Resources
  - Network
  - Memory usage
  - Disk use, latency
  - Threads
- Dashboard for cloud administration.



# "Splunking"



# The Structure Spectrum





# Graph Data

Lots of interesting data has a graph structure:

- Social networks
- Communication networks
- Computer Networks
- Road networks
- Citations
- Collaborations/Relationships
- ...

Some of these graphs can get quite large (e.g., Facebook\* user graph)

