

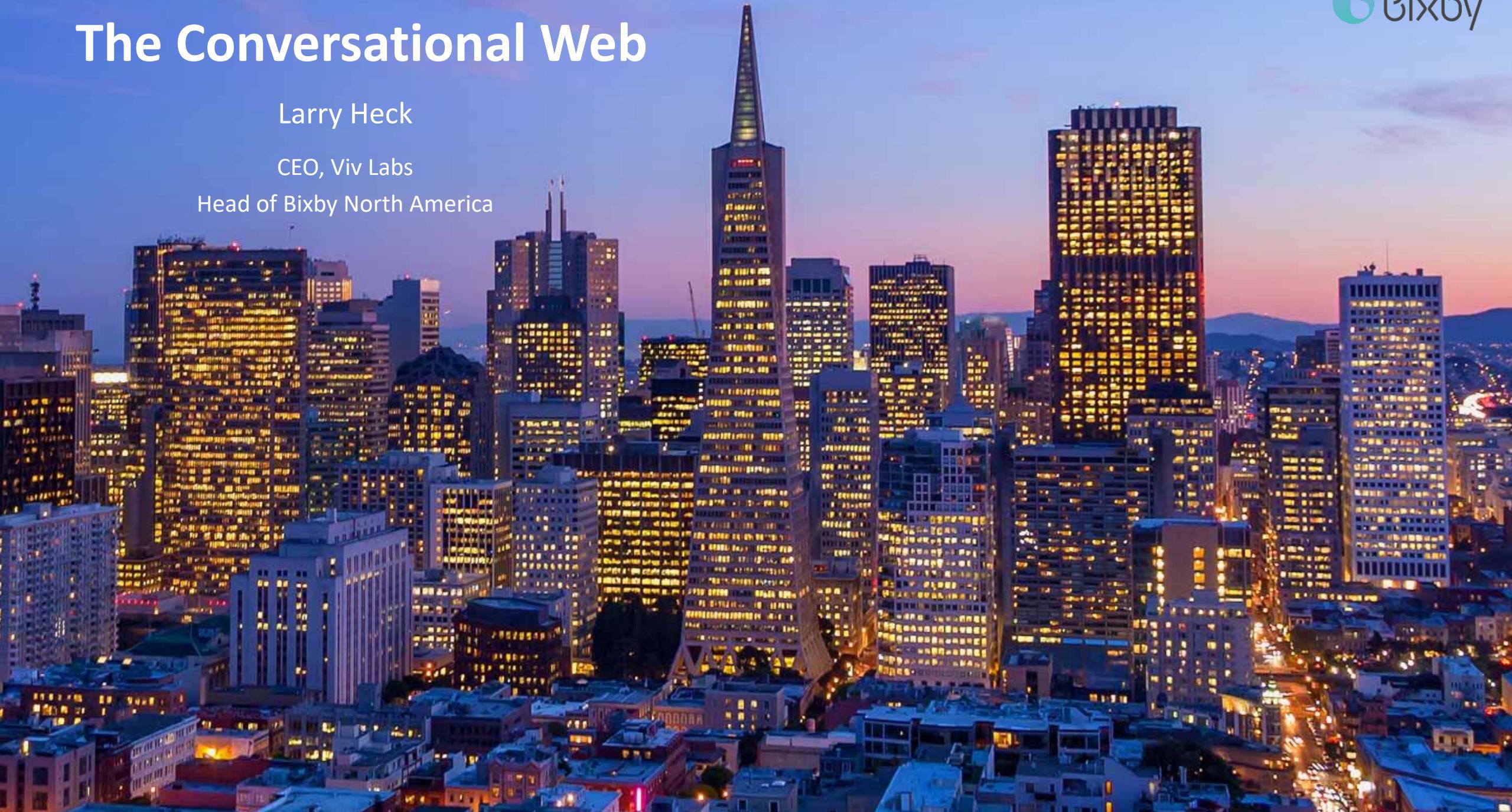


The Conversational Web

Larry Heck

CEO, Viv Labs

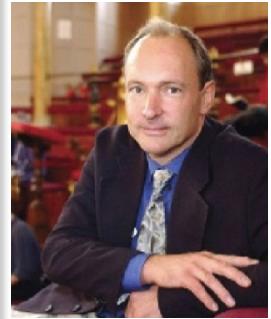
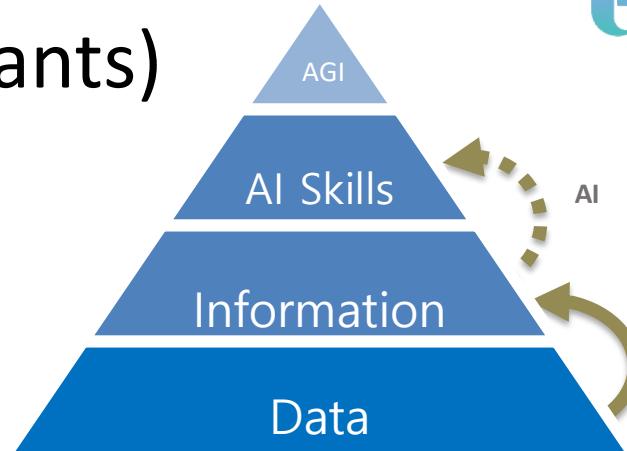
Head of Bixby North America





The Emergence of Conversational AI (Personal Assistants)

A Similar Evolution to Web Search



1991

World Wide Web Goes Online
With help of Robert Cailliau, Tim Berners-Lee writes the first world wide web server. It goes online world-wide via the Internet network in the summer of 1991.

Directory

- www.yahoo.com
- www.google.com
- www.aol.com
- www.pets.com
- www.kozmo.com
- www.ngm.com
- www.etoys.com
- www.boo.com
- www.flooz.com
- www.xyz.com
- www.Go.com
- www.classy.com

1994

Web Directories

In the early days of the Web, companies like Yahoo! and Galaxy created online directories to help users find what they needed. Between 1994-1996, the Web grows from 60K documents to millions of documents.



2000

Searching the Web

Since 1997, Larry Page and Sergey Brin go on to revolutionize web search by counting site links and ranking accordingly.

1991

1994

2000

2007

2010

2012

2016



2007

Appification of the Web Begins

Apple launches the iPhone and announces that it would support third-party applications, which users would access via the Internet. The first app, "OneTrip", keeps track of a user's shopping list.



2010-present

Era of Personal Assistants

Siri is acquired by Apple which starts a new era of AI



2007-2012

Apps Marketplaces

Marketplaces by Apple, Google and Microsoft offer directories to help users find apps. Between 2007-2012, the marketplaces grow from 0 to 600K+400K+70K apps, a \$12B industry.



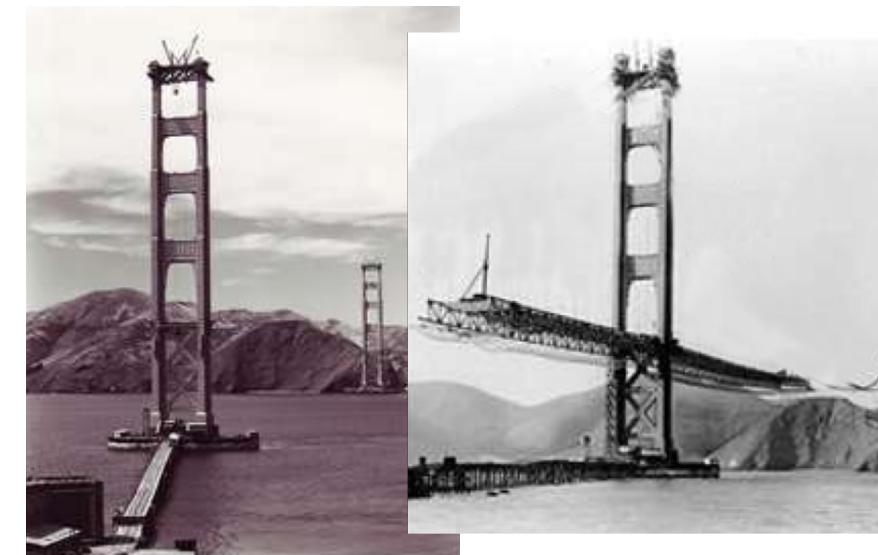
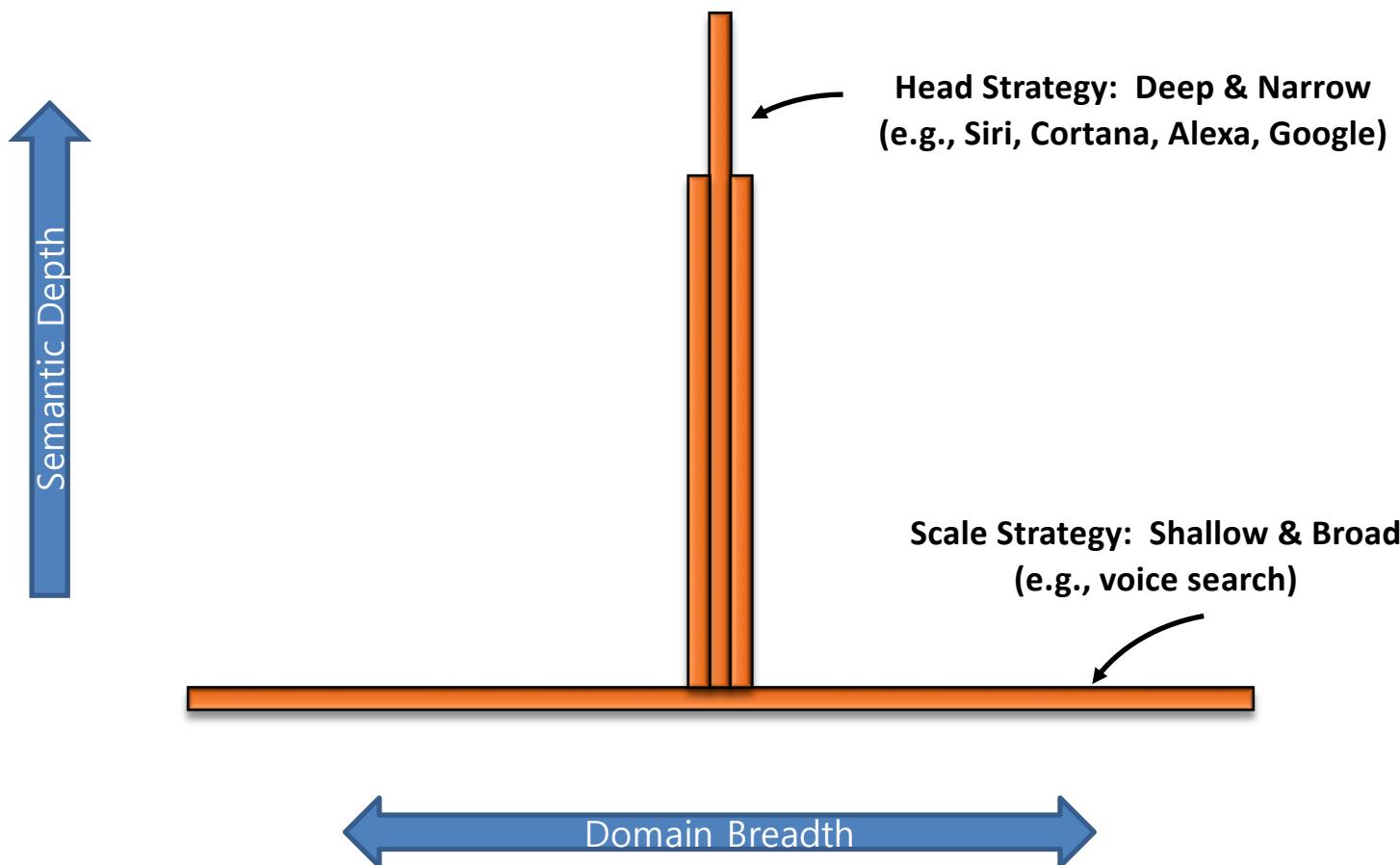
2016-present

AI Skills Marketplaces

Siri is Personal Assistants scale through developer tools and marketplaces to publish AI Skills

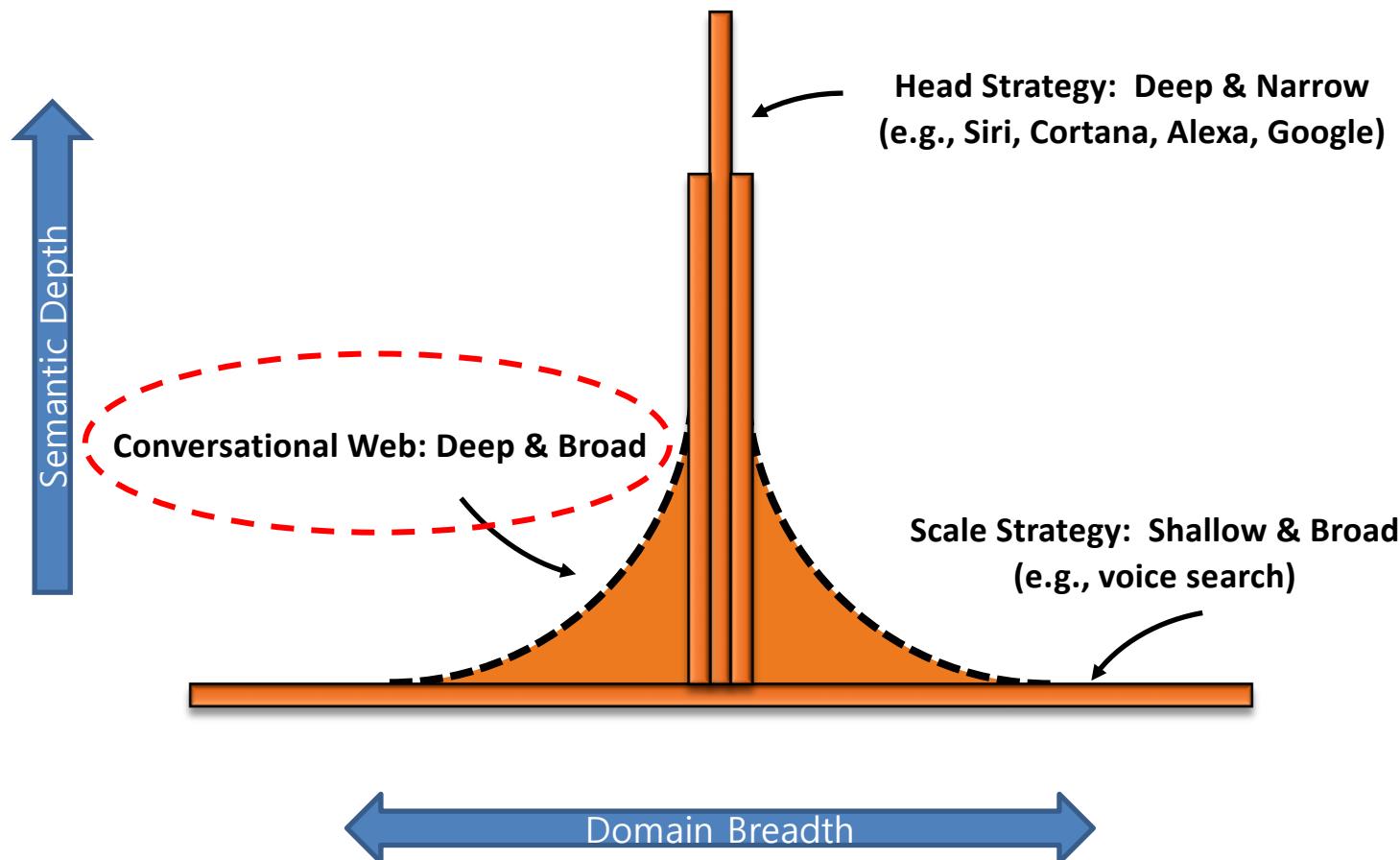
Virtual Personal Assistants

One Domain at a Time



Virtual Personal Assistants

How to Achieve Both Depth & Breadth?



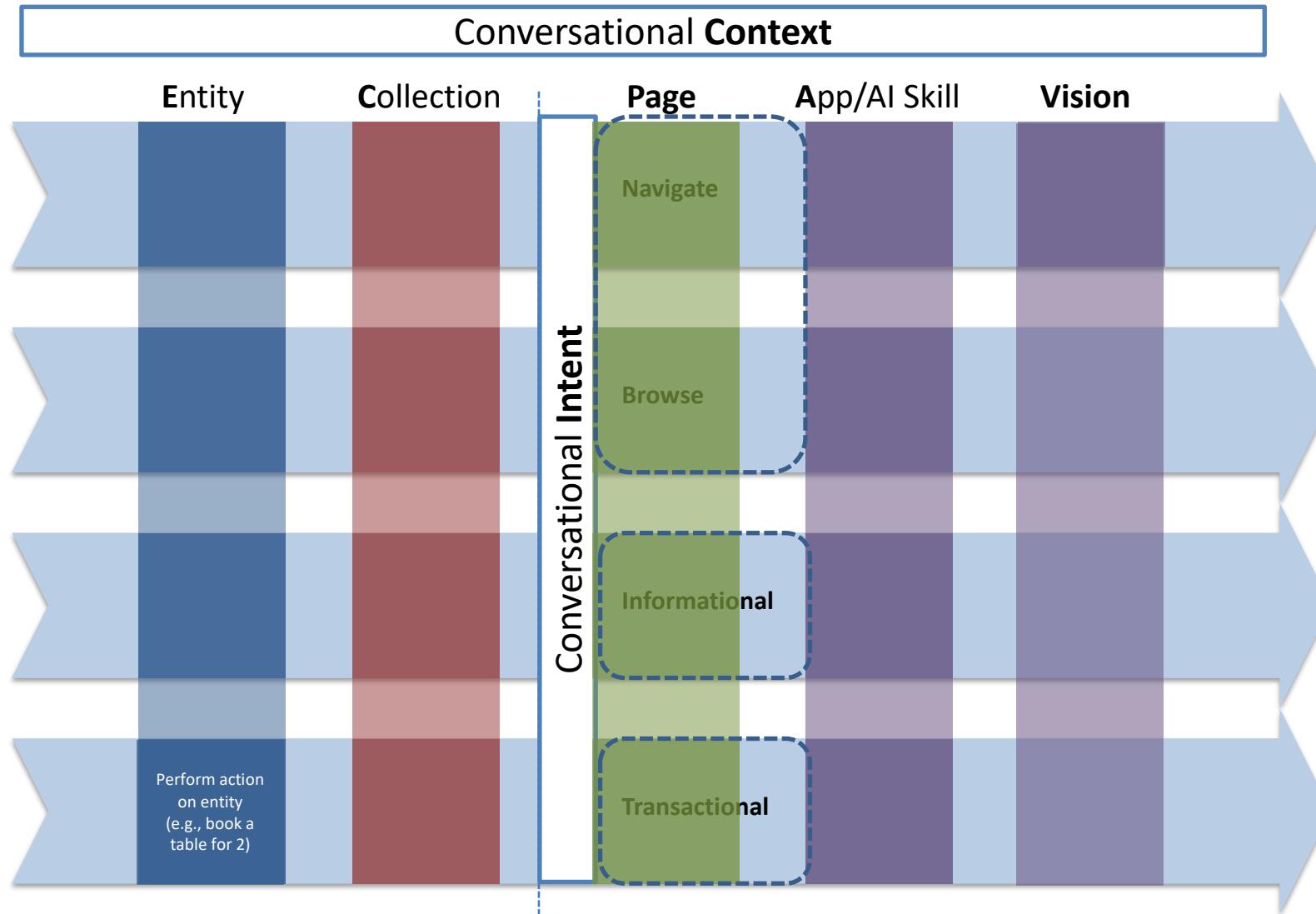
Conversational Web

Seamless Conversational Experiences Across Your Life



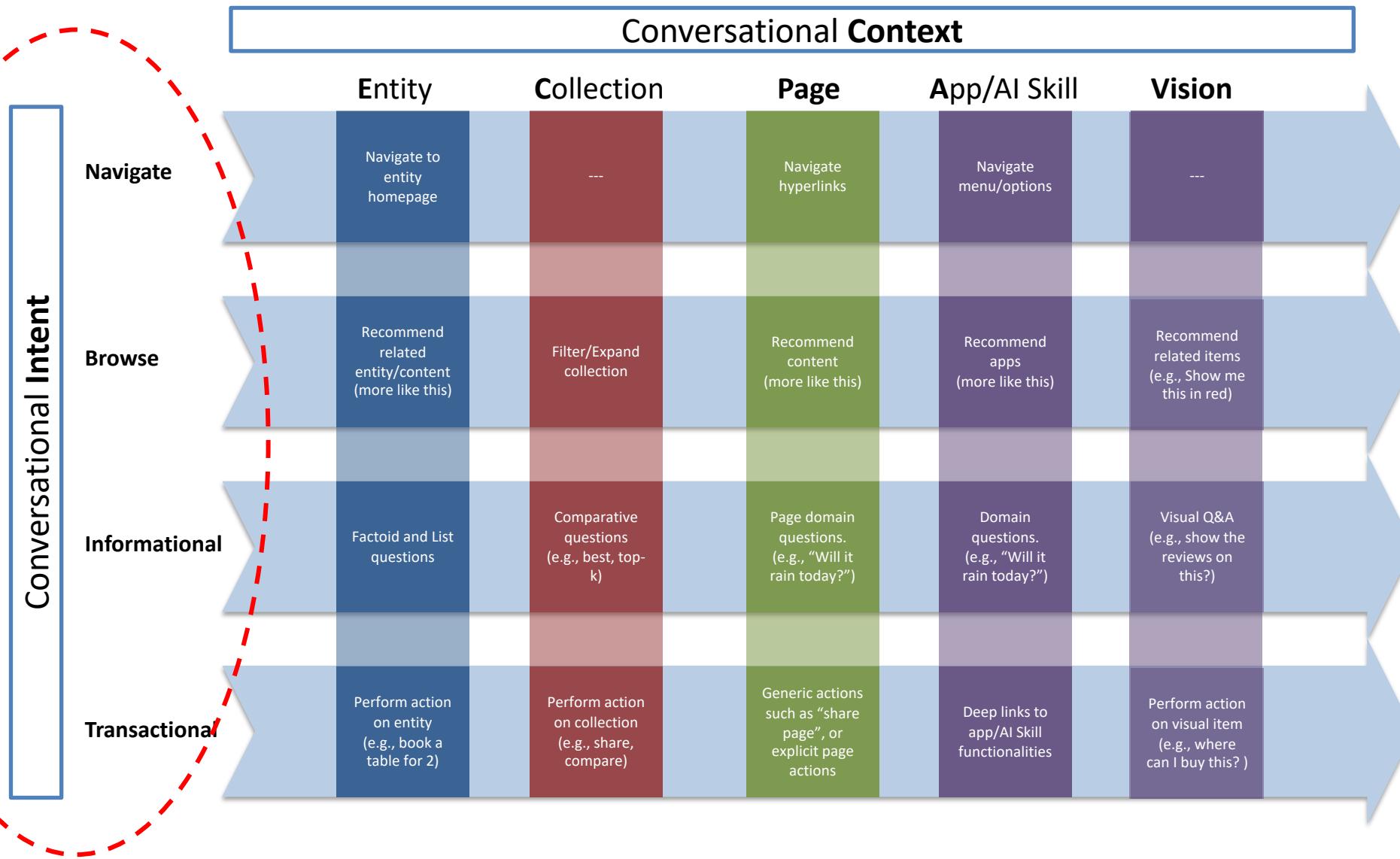
Taxonomy of the Conversational Web

Conversational Intent and Context



Taxonomy of the Conversational Web

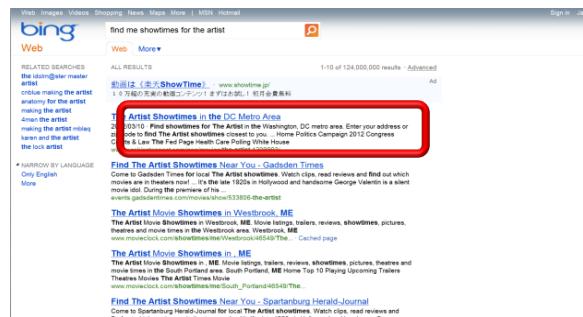
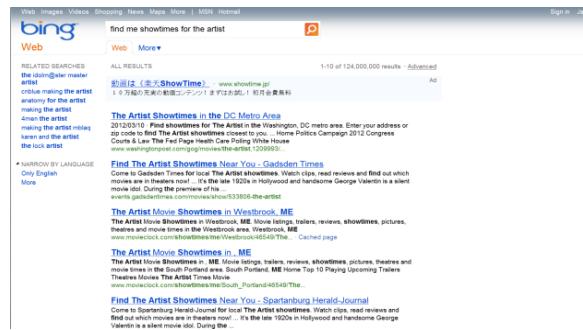
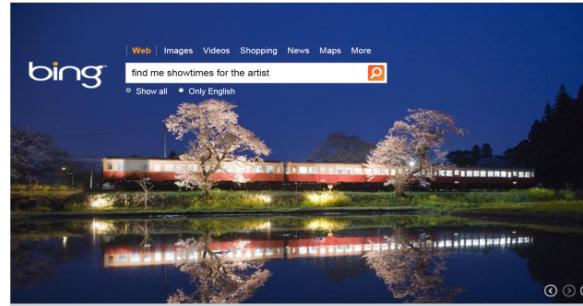
Conversational Intent and Context



Conversational Intents

Web of Intents

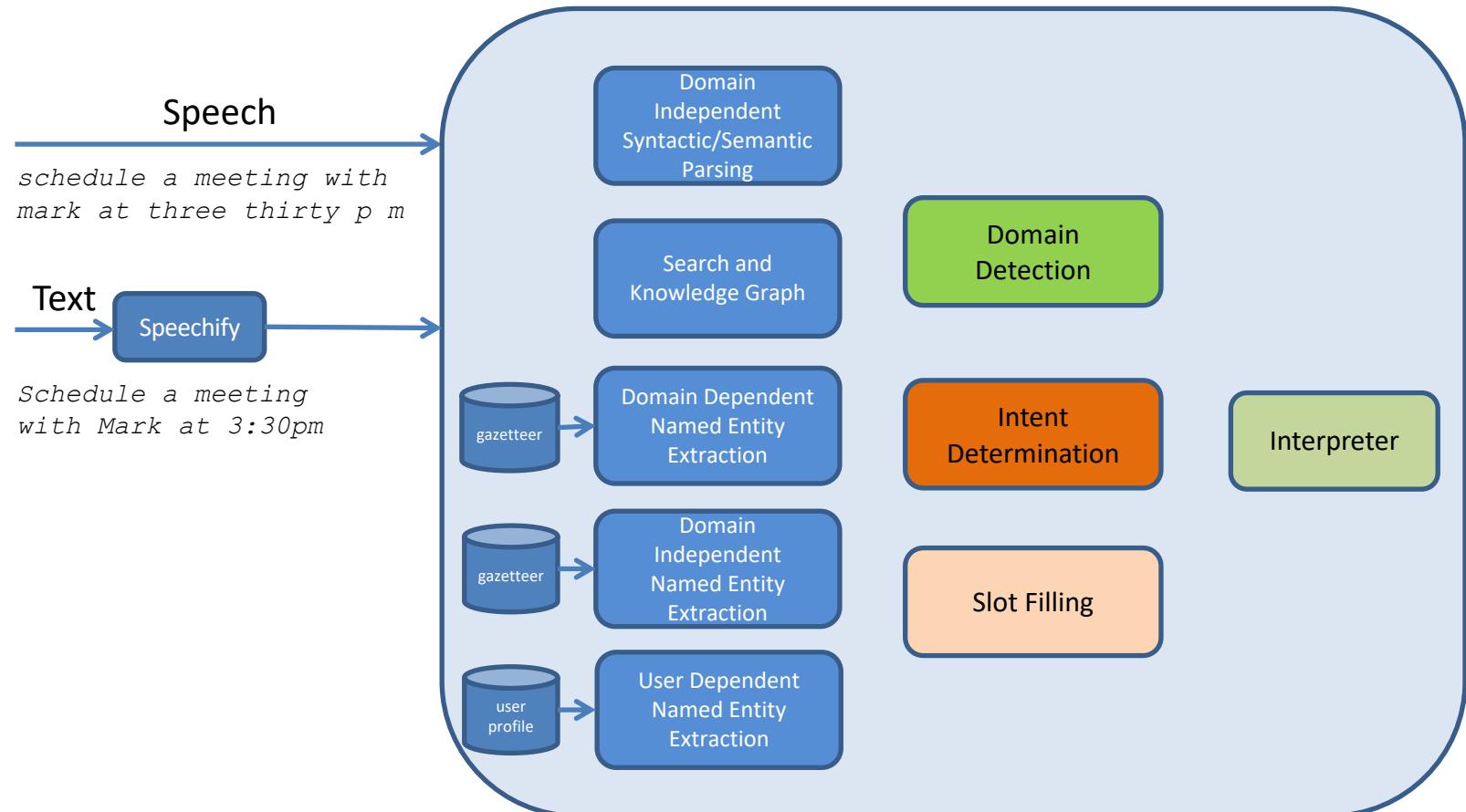
- “Web of Intents” – massive (1B+ queries-clicks/day) data with implicit semantics related to surface forms
- Highly leveraged for machine learning-based web search relevance
 - Queries
 - URLs returned by the search engines and clicked by the users
 - Page Navigation
 - Dwell Times
- Possible to extract information from
 - Multiple users’ behavior: high-quality query-click pairs
 - Search sessions
 - Users’ reformulation of their queries.
 - Modeling interactions, sequencing of intents.





Conversational Intents

Web of Intents



```
<calendar parse="schedule a meeting with mark at three thirty p m">
  <intent parse="add to calendar" />
  <cal_start_time parse="three thirty p m" norm=3:30pm/>
  <cal_attendees parse="mark" norm="mark smith"/>  </calendar>
```

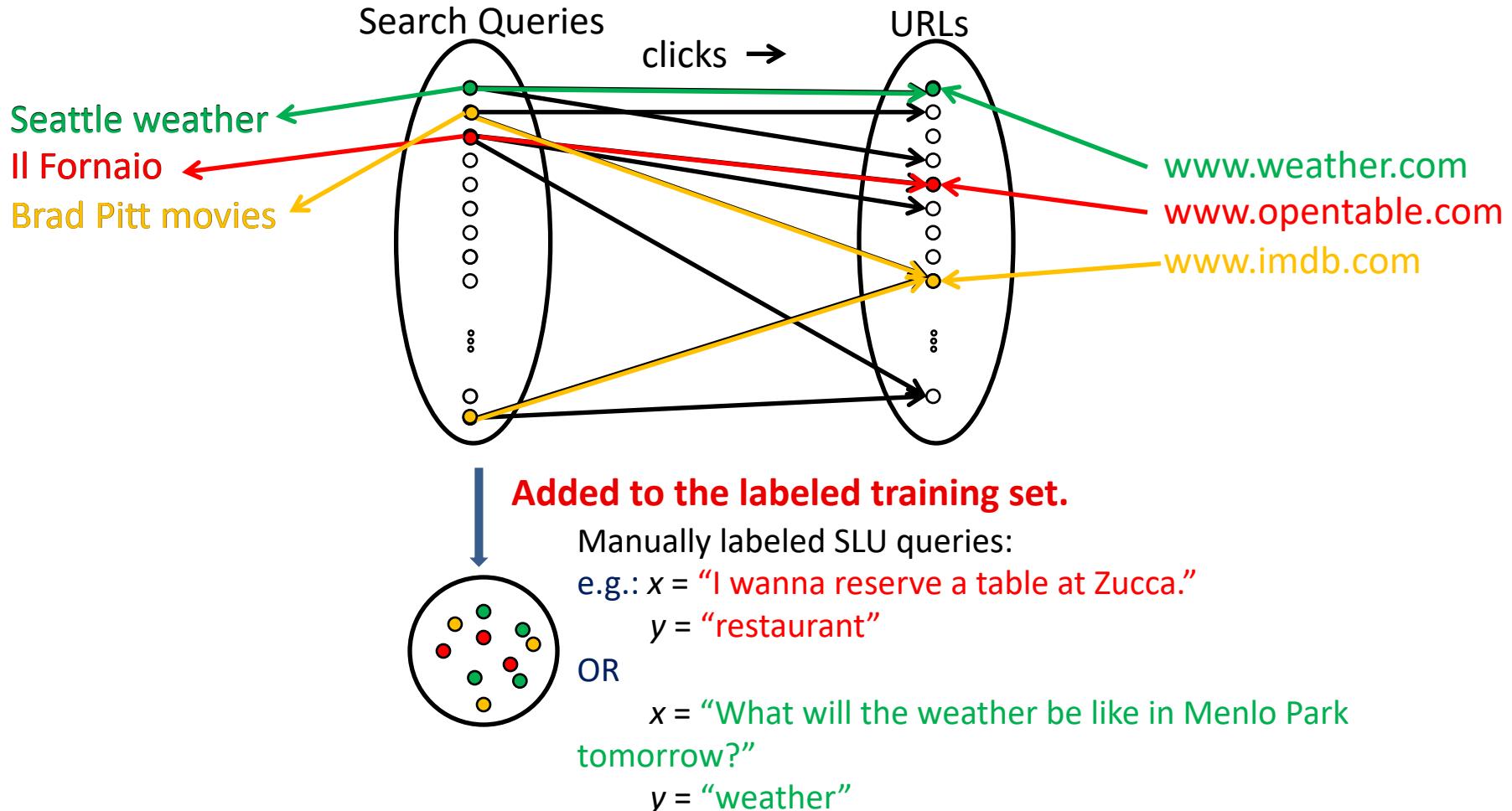
Conversational Intents

Key Publications

Bootstrapping domain detection using query click logs for new domains	Hakkani-Tür, Dilek; Tur, Gokhan; Heck, Larry; Shriberg, Elizabeth	Interspeech (2011)
Exploiting query click logs for utterance domain detection in spoken language understanding	Hakkani-Tür, Dilek; Heck, Larry; Tur, Gokhan	ICASSP (2011)
Sentence simplification for spoken language understanding	Tur, Gokhan; Hakkani-Tür, Dilek; Heck, Larry; Parthasarathy, Sarangarajan;	ICASSP (2011)
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Zero-shot learning for semantic utterance classification	Dauphin, Yann N; Tur, Gokhan; Hakkani-Tur, Dilek; Heck, Larry	arXiv:1401.0509 (2013)

Conversational Intents

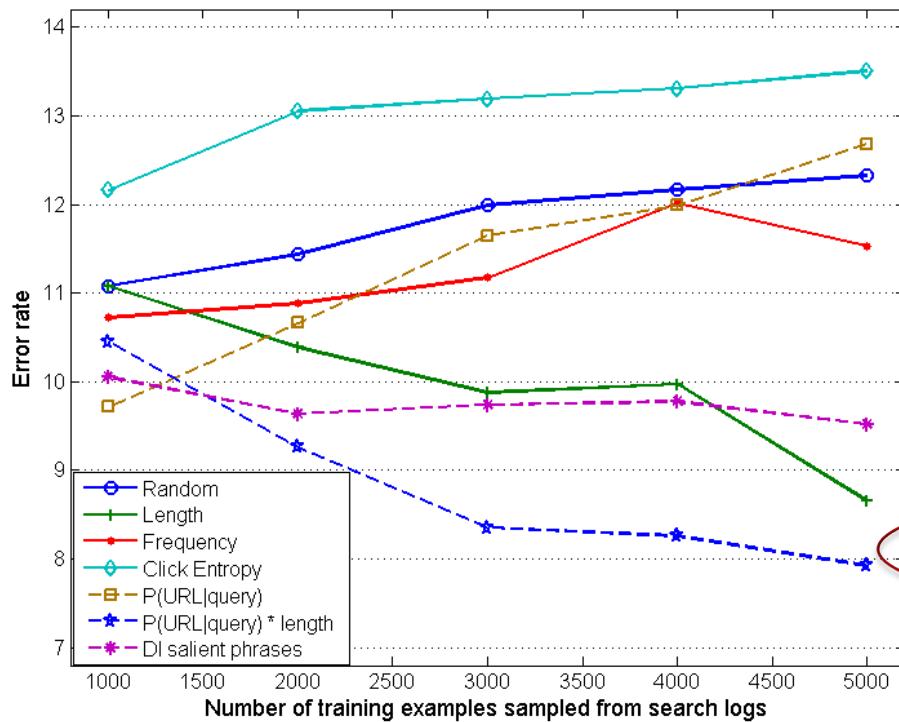
Bootstrapping Domain Classification Using Search Query-Click logs (2011)



Conversational Intents

Bootstrapping Domain Classification Using Search Query-Click logs (2011)

Approach: Web search logs (clicks/queries) for unsupervised learning of new domain



Experiment	Error Rate
Baseline: No domain data	27.5%
All web queries	18.9%
Supervised	6.2%
Unsupervised Method Web search log-based features	8.0%

Conversational Intents

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Conversational Intents

Translating Natural Language Utterances to Search Queries (2012)

Clusters:

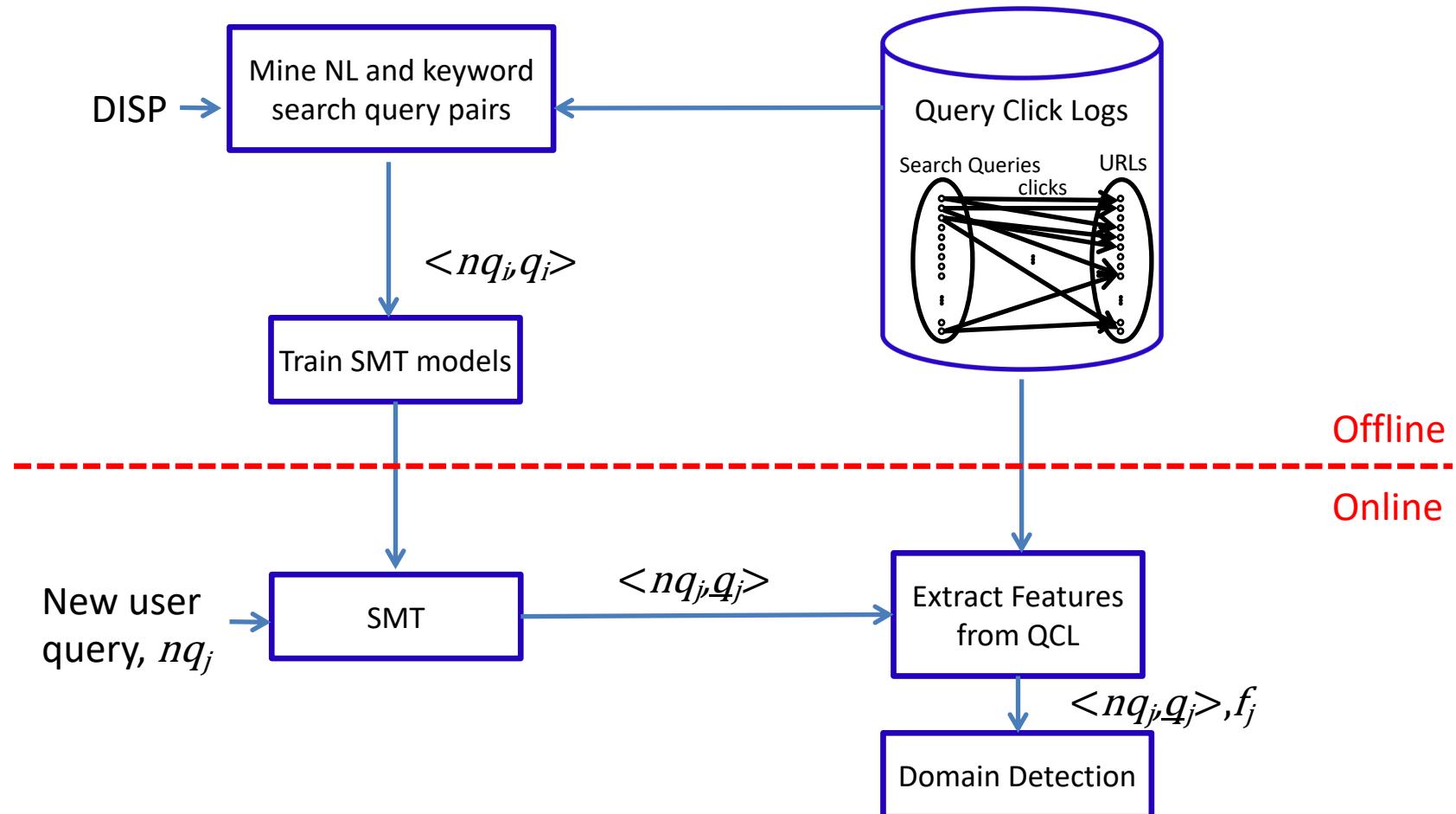
show me a resume sample show me a resume show me a sample resume ... resume samples	what are my bonds worth what are my savings bonds worth what are savings bonds worth what are bonds worth what are my series ee bonds worth what are us savings bonds worth what are ee bonds worth what are my us savings bonds worth what are my ee bonds worth what are series ee bonds worth what are savings bonds what's my savings bond worth ... savings bond calculator	what are the symptoms of flu what are symptoms of the flu what are the flu symptoms what are flu symptoms what are the symptoms of the flu what are flu like symptoms what are symptoms of flu what are the symptoms of the flu what are the symptoms of flu what are the flu symptoms ... flu symptoms
when is passover celebrated when is pass over when is passover 2011 when is passover this year when is passover when is passover 2010 when is the passover ... passover dates		

NL Search Query (<i>DISP</i> are in <i>italics</i>)	Keyword Query
<i>what are the signs of throat cancer</i>	throat cancer symptoms
<i>how many calories do I need in a day</i>	calories per day
<i>what are the biggest us companies</i>	fortune 500 companies
<i>are there any diet pills that actually work</i>	diet pills that work
<i>how do I know if I am anemic</i>	anemic

Similarity between NL search query and the keyword query allows for sorting and filtering pairs.

Conversational Intents

Translating Natural Language Utterances to Search Queries (2012)



Conversational Intents

Translating Natural Language Utterances to Search Queries (2012)

20% ERR

Approach	Overall ER	ER on NL subset	ER on query-like subset	ER on subset with DISP	ER on subset without DISP
1: Word 1,2,3-grams (n-grams)	10.6%	11.3%	9.3%	9.9%	10.8%
2: n-grams + syntax + SMT-1	9.4%	10.7%	6.8%	10.1%	9.1%
3: n-grams + SMT 2	9.3%	10.9%	6.2%	10.3%	8.9%
4: n-grams + SMT-1+2	8.5%	9.9%	5.8%	9.2%	8.2%

- Statistical Machine Translation (SMT) of NL to “keyword” queries is promising!
- Primary source of gain: leverage the learning “flywheel” of web searching/browsing

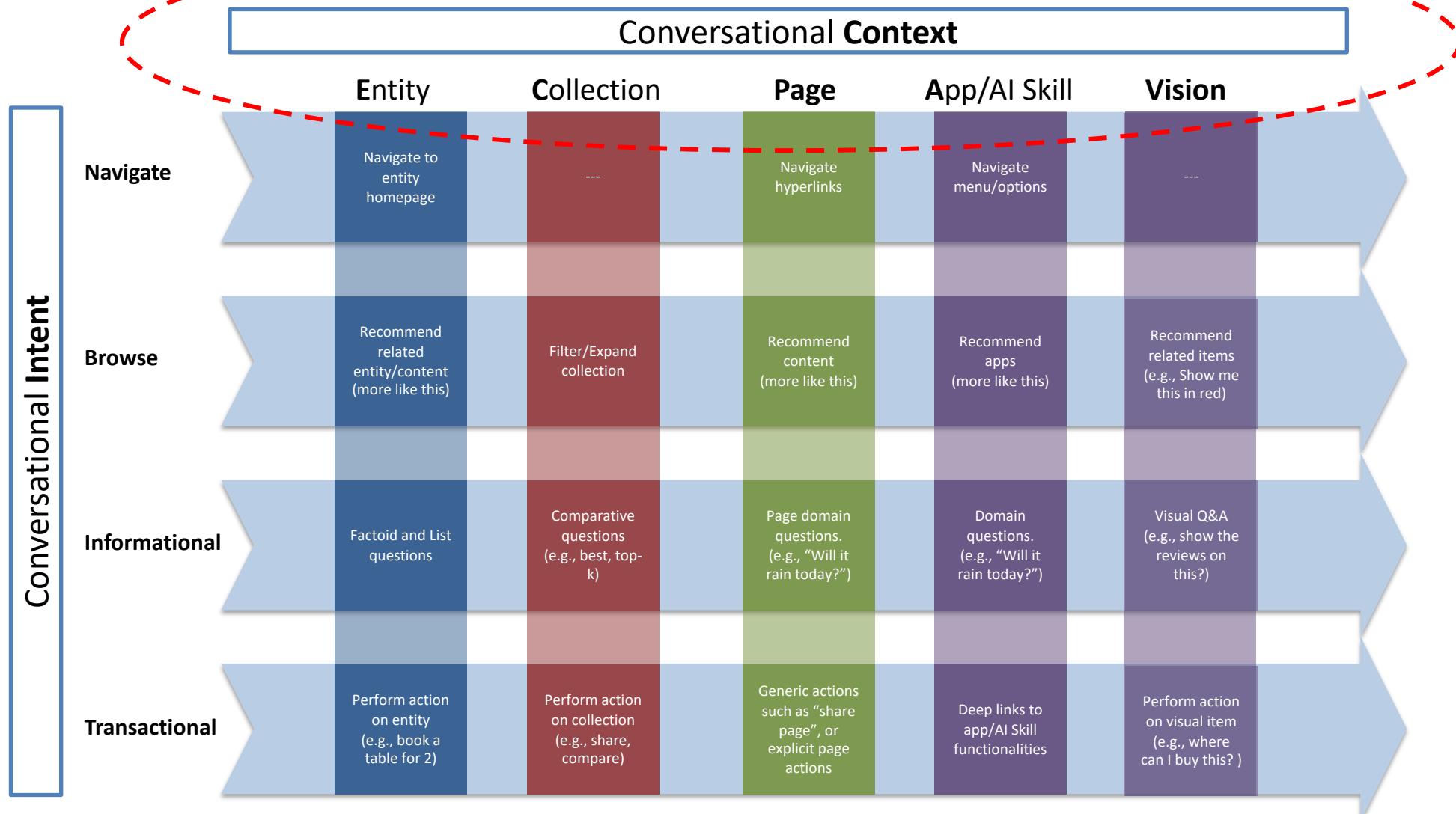
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Taxonomy of the Conversational Web

Conversational Intent and Context



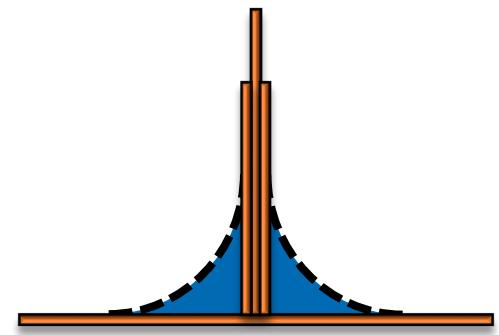
Conversational Context – Situated Dialogue

Key Publications

Multi-modal conversational search and browse	Heck, Larry; et al	Workshop on Speech, Language and Audio in Multimedia (2013)
Learning when to listen: Detecting system-addressed speech in human-human-computer dialog	Shriberg, Elizabeth; Stolcke, Andreas; Hakkani-Tür, Dilek; Heck, Larry;	Interspeech (2012)
Eye gaze for spoken language understanding in multi-modal conversational interactions	Hakkani-Tür, Dilek; Slaney, Malcolm; Celikyilmaz, Asli; Heck, Larry;	International Conference on Multimodal Interaction (2014)

Conversational Context – Situated Dialogue

Conversational Browser with Voice+Gesture (2012)



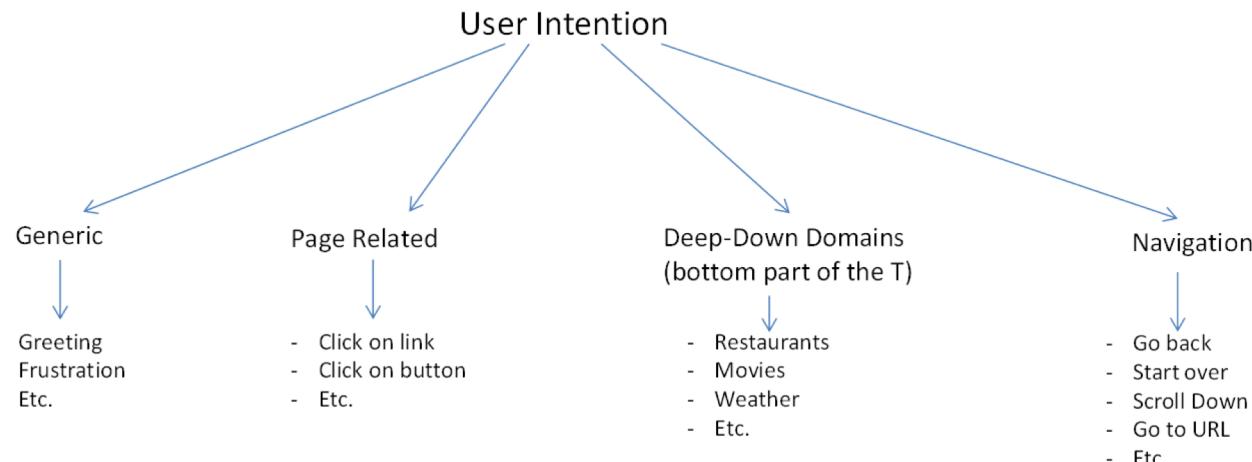
<https://www.Microsoft.com/en-us/research/video/louise-personal-assistant-tv>

Conversational Context – Situated Dialogue

Conversational Browser with Voice+Gesture (2012)

Browsing to a new web page or App affects ASR and SLU

- ASR: Dynamic adaptation of LMs to ngrams of page content → **16% ERR in WER**
- SLU:
 - Add 100s of **click intent** actions to **static SLU**
 - Multi-tiered logic determines final intent



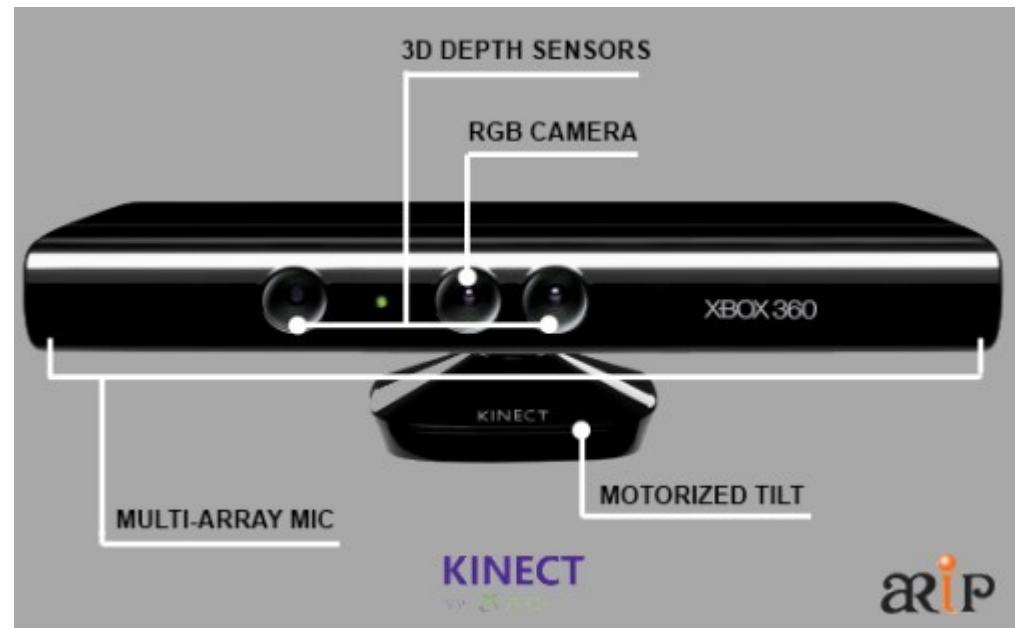
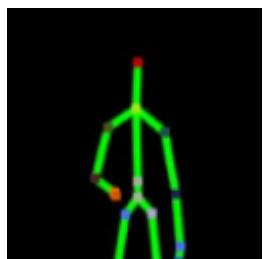
Conversational Context – Situated Dialogue

Conversational Browser with Voice+Gesture (2012)

Multimodal Sensor for Study: Kinect™

- RGB camera
- Depth sensor
- Multi-array microphone running proprietary software

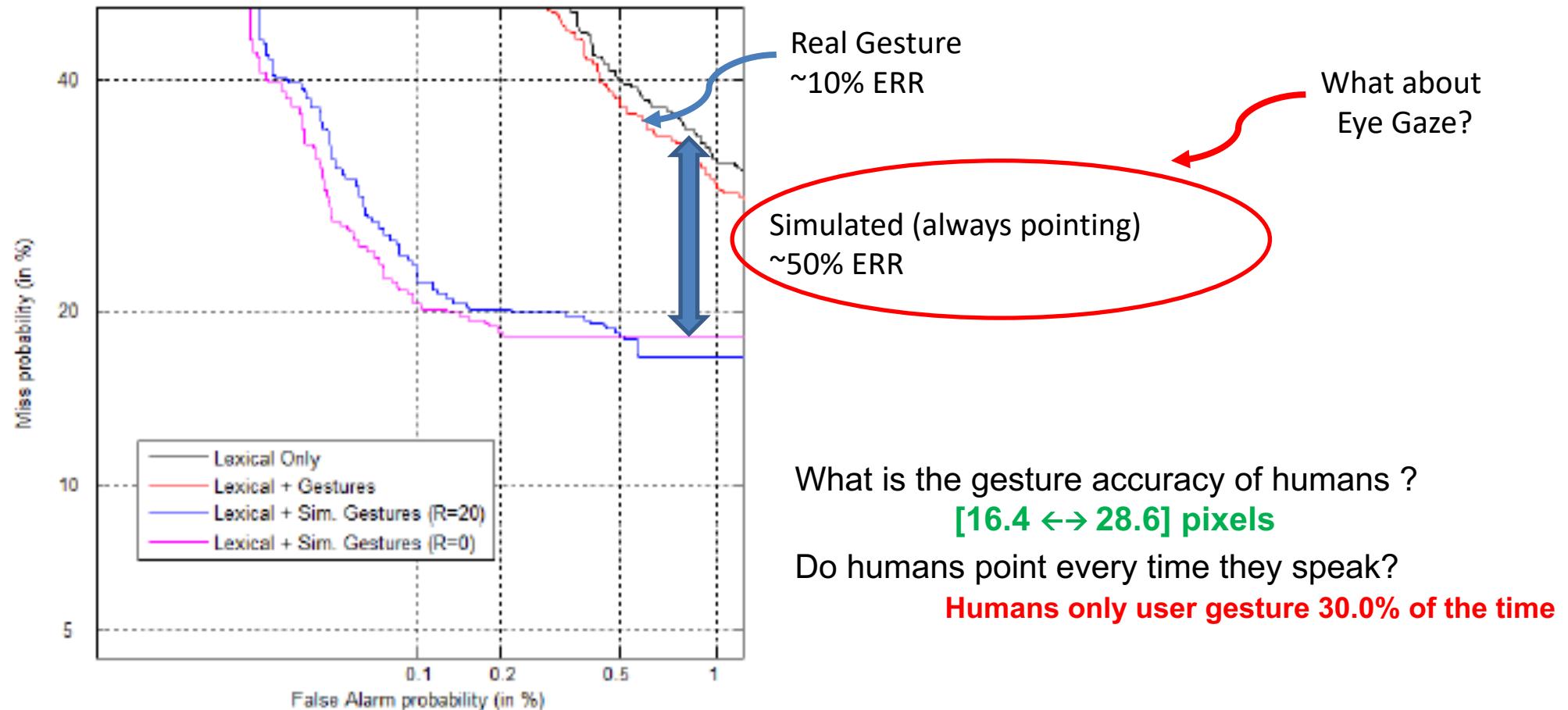
Kinect enables full-body 3D motion capture, facial recognition and voice recognition



ariP

Conversational Context – Situated Dialogue

Conversational Browser with Voice+Gesture (2012)



Conversational Context – Situated Dialogue

To dig deeper...

Multi-modal conversational search and browse	Heck, Larry; et al	Workshop on Speech, Language and Audio in Multimedia (2013)
Learning when to listen: Detecting system-addressed speech in human-human-computer dialog	Shriberg, Elizabeth; Stolcke, Andreas; Hakkani-Tür, Dilek; Heck, Larry;	Interspeech (2012)
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Conversational Context – Situated Dialogue

Broad Variety of Context

Visual + Gesture + Eye Gaze

- Passive: display provides context (priors) for conversation
- Active: **multi-modal** interaction with entity(ies)

Dialogue

Coherence (topic, speaker, etc.) of multi-turn conversations

Personal

Personal information (spouse, profession, etc.), historical interactions, preferences

Location (Geo)

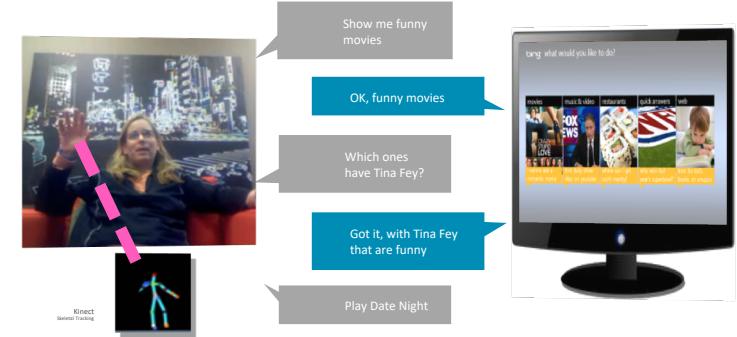
Current location influences conversational interactions

Time/Day/Season

Conversational topics related to the moment in time

Knowledge

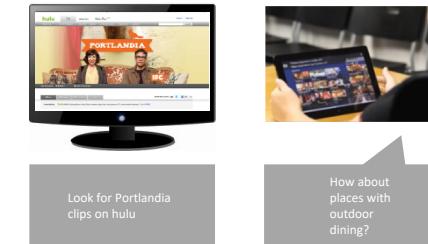
Knowledge of the domain/topic/user



Personal Assistant for Phones

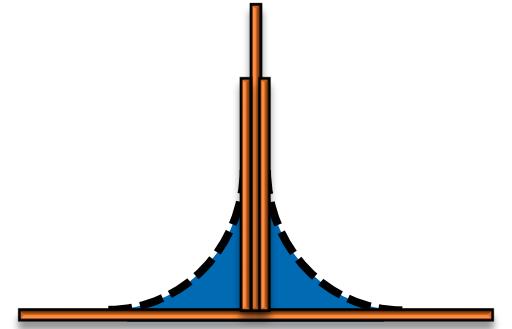


Other Screens:



Conversational Context - Knowledge

Knowledge: Foundation of Conversations



A vast majority of user interactions are with people, locations, things (**entities**).

Knowledge refers to these **entities/concepts** and to how they are interrelated.

The dual-role of knowledge

People seek to **browse** and **find information** about **entities** and to **transact** on them.

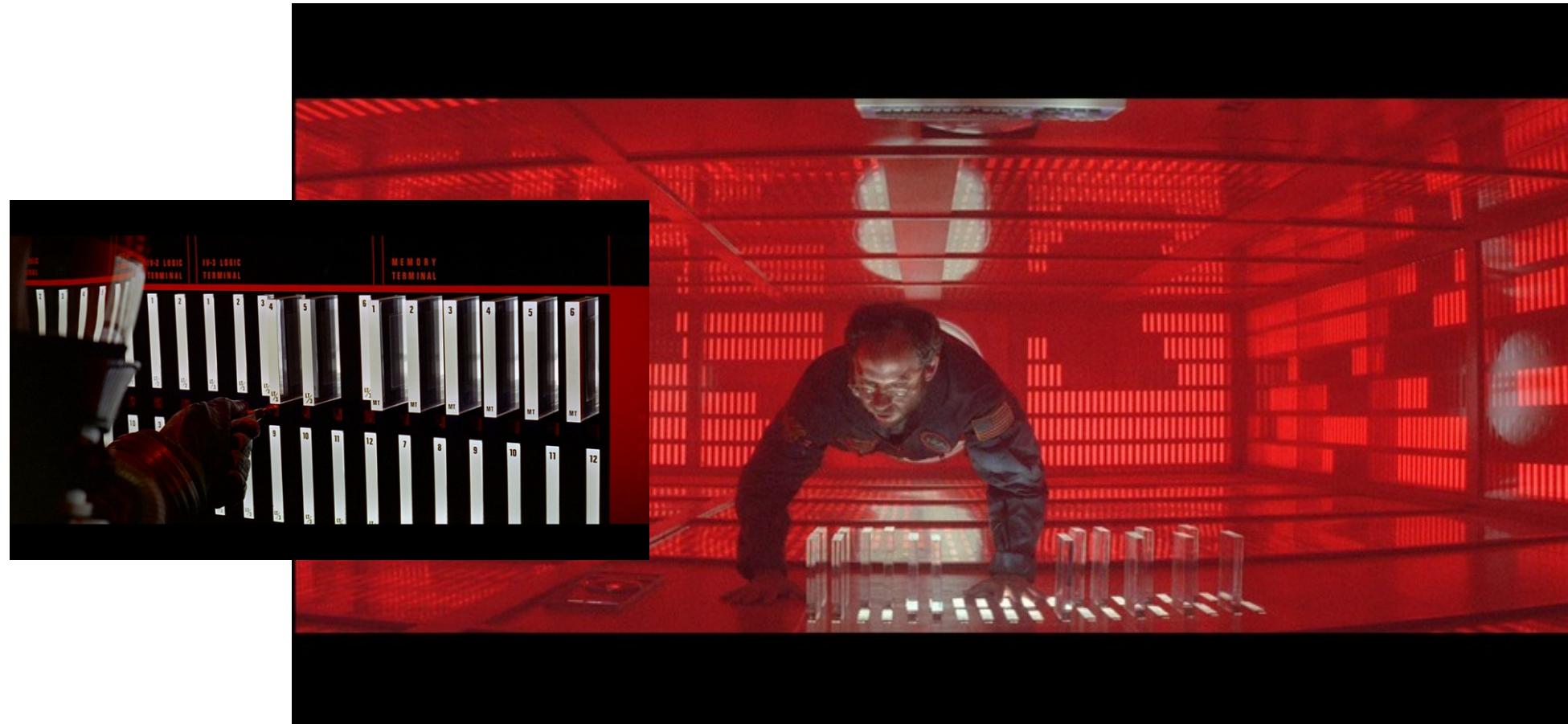
Knowledge serves as a **grounding for conversations**.



Conversational Context - Knowledge

Knowledge: Foundation of Conversations

Vision: Push-button Conversational AI from a Knowledge (sub)Graph

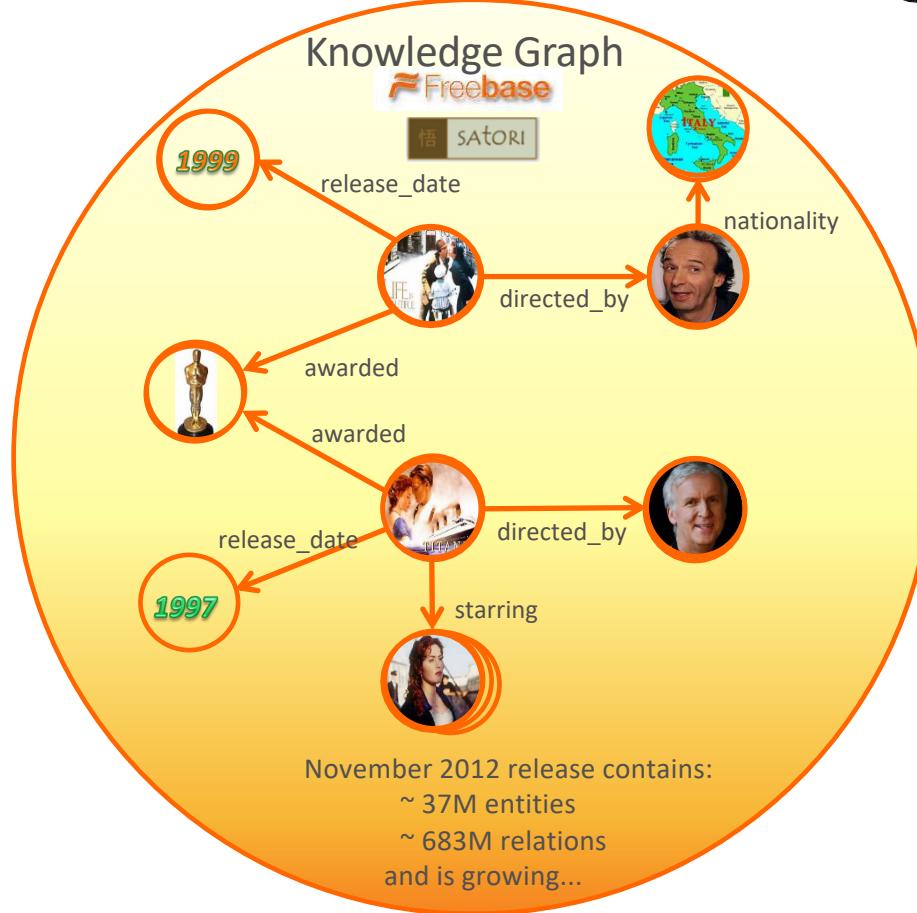


Conversational Context - Knowledge

Entity Linking and Relations

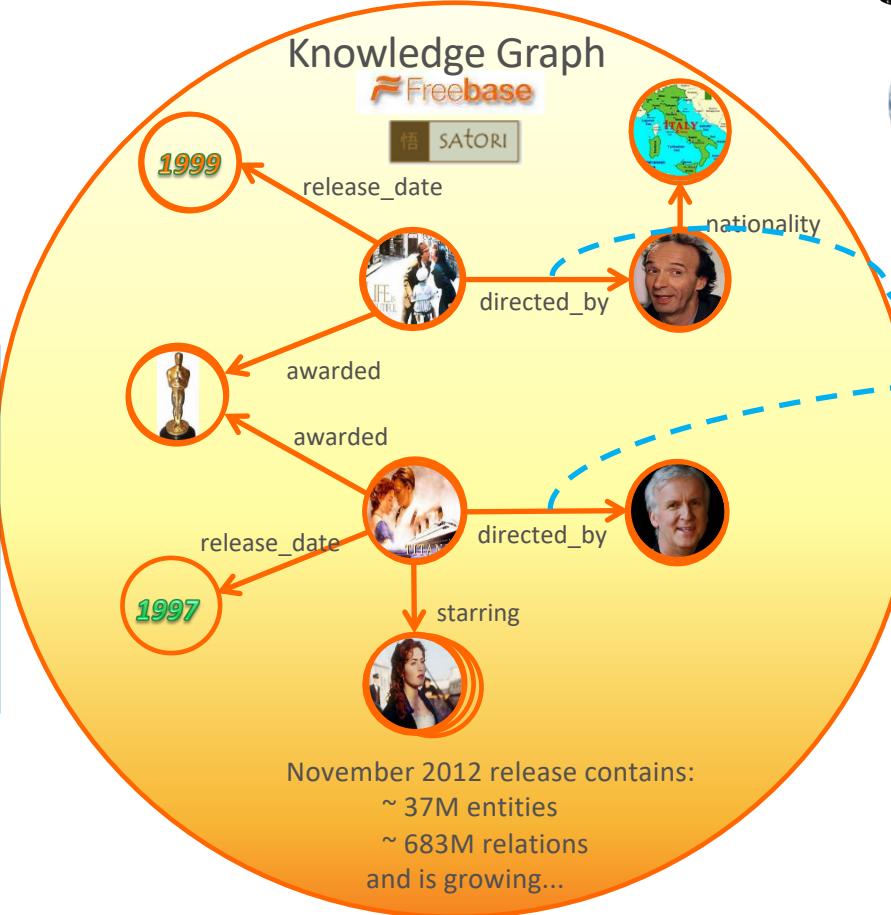
Exploiting the semantic web for unsupervised spoken language understanding	Heck, Larry; Hakkani-Tür, Dilek;	IEEE Spoken Language Technology Workshop (2012)
Leveraging knowledge graphs for web-scale unsupervised semantic parsing	Heck, Larry; Hakkani-Tür, Dilek; Tur, Gokhan;	Interspeech (2013)
Using a knowledge graph and query click logs for unsupervised learning of relation detection	Hakkani-Tür, Dilek; Heck, Larry; Tur, Gokhan;	ICASSP (2013)
Exploiting the semantic web for unsupervised natural language semantic parsing	Tur, Gokhan; Jeong, Minwoo; Wang, Ye-Yi; Hakkani-Tür, Dilek; Heck, Larry;	Interspeech (2012)
Leveraging semantic web search and browse sessions for multi-turn spoken dialog systems	Wang, Lu; Heck, Larry; Hakkani-Tür, Dilek;	ICASSP (2014)
Extending domain coverage of language understanding systems via intent transfer between domains using knowledge graphs and search query click logs	El-Kahky, Ali; Liu, Xiaohu; Sarikaya, Ruhi; Tur, Gokhan; Hakkani-Tür, Dilek; Heck, Larry;	ICASSP (2014)
Probabilistic enrichment of knowledge graph entities for relation detection in conversational understanding	Hakkani-Tür, Dilek; Celikyilmaz, Asli; Heck, Larry; Tur, Gokhan; Zweig, Geoff;	Interspeech (2014)
Deep learning of knowledge graph embeddings for semantic parsing of Twitter dialogs	Heck, Larry; Huang, Hongzhao;	IEEE Global Conference on Signal and Information Processing (2014)
Leveraging deep neural networks and knowledge graphs for entity disambiguation	Huang, Hongzhao; Heck, Larry; Ji, Heng;	arXiv preprint arXiv:1504.07678

Linking Data to the Knowledge Graph



Linking Data to the Knowledge Graph

- Search for all pairs of entities connected by the same relation [Ravichandran & Hovy, 2002]
- Extract relation patterns from these



1

bing



Web Search

Movie-Director search queries:

"Life is beautiful" and "Roberto Benigni"
"Titanic" and "James Cameron"
...

Search Results

Italy's rubber-faced funnyman Roberto Benigni accomplishes ...
Life Is Beautiful is a 1997 Italian film which tells the story of a ...
Titanic is a 1997 American film directed by James Cameron...
James Cameron directed Titanic and he did the best job you...

NL Patterns

Movie-name directed by Director-name
Director-name's Movie-name
Director-name directed Movie-name
...

Linking Data to the Knowledge Graph

2



Wikipedia
& other document sources

Article Talk Read Edit View

Life Is Beautiful

From Wikipedia, the free encyclopedia (Redirected from Life is beautiful)

For other uses, see *Life Is Beautiful* (disambiguation).

Life Is Beautiful (Italian: *La vita è bella*) is a 1997 Italian comedy-drama film directed by and starring Roberto Benigni. Benigni plays Guido Orefice, a Jewish Italian book shop owner, who must employ his fertile imagination to shield his son from the horrors of internment in a Nazi concentration camp. Part of the film came from Benigni's own family history; before Roberto's birth, his father had survived three years of internment at the Bergen-Belsen concentration camp. The film was a critical and financial success, winning Benigni the Academy Award for Best Actor at the 71st Academy Awards as well as the Academy Award for Best Original Dramatic Score and the Academy Award for Best Foreign Language Film.

Contents [hide]
1 Plot

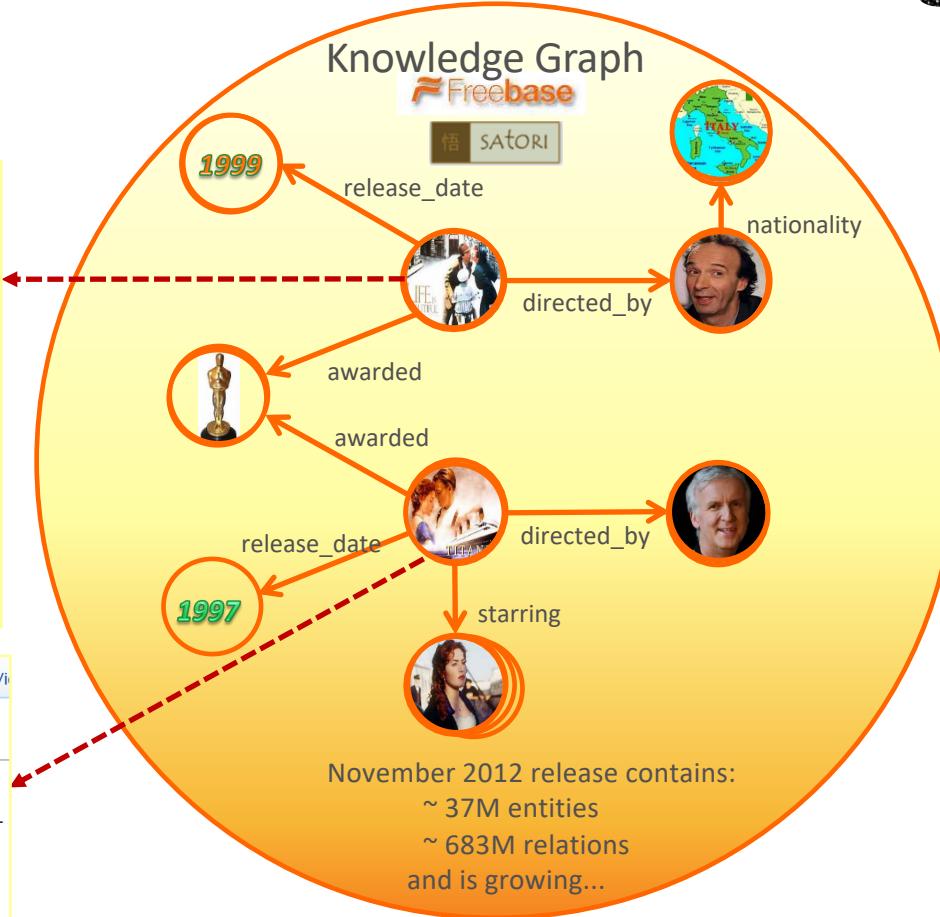
Article Talk Read View source View

Titanic (1997 film)

From Wikipedia, the free encyclopedia

Titanic is a 1997 American epic romantic disaster film directed, written, co-produced, and co-edited by James Cameron. A fictionalized account of the sinking of the RMS *Titanic*, it stars Leonardo DiCaprio and Kate Winslet as members of different social classes who fall in love aboard the ship during its ill-fated maiden voyage.

Cameron's inspiration for the film was predicated on his fascination with shipwrecks; he wanted to convey the emotional message of the tragedy, and felt that a love story interspersed with the human loss would be essential to achieving this. Production on the film began in 1995, when Cameron shot footage of the actual *Titanic* wreck. The modern scenes were shot on board the *Akademik Mstislav Keldysh*, which Cameron had used as a base when filming the wreck. A reconstruction of the *Titanic* was built at Playas de Rosarito, Baja California, and scale models and computer-generated imagery were also used to recreate the sinking. The film was partially funded by Paramount Pictures and 20th Century Fox, and, at the time, was the most expensive film ever made, with an estimated budget of \$200 million.



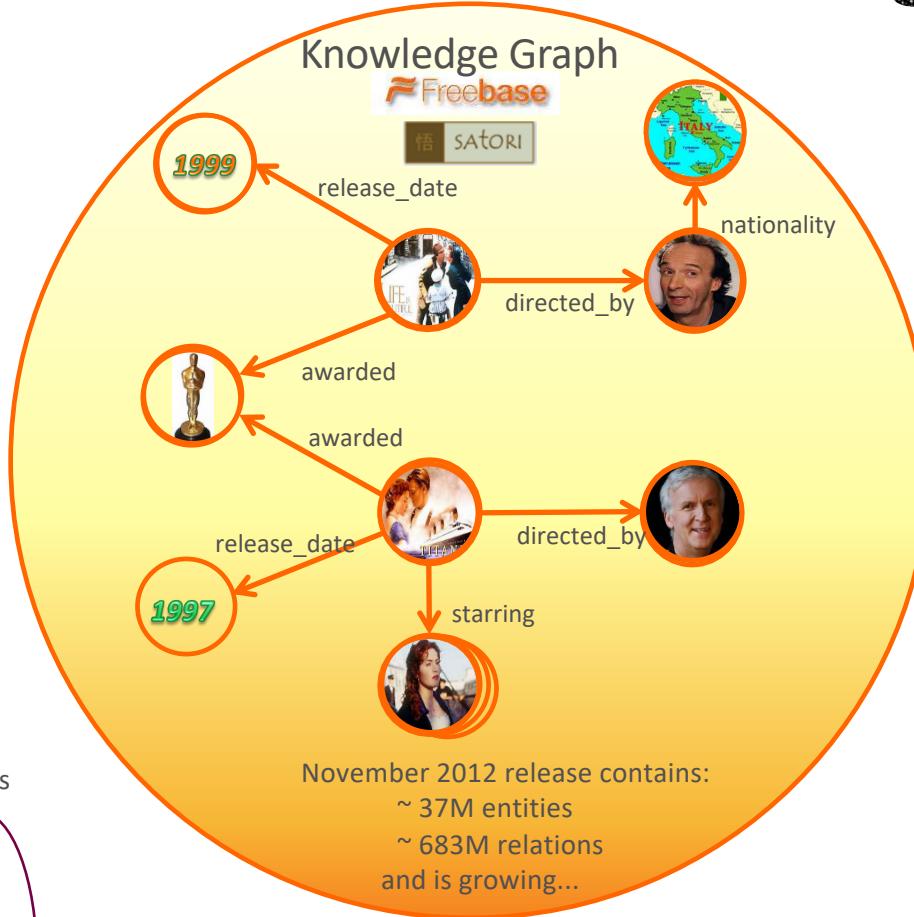
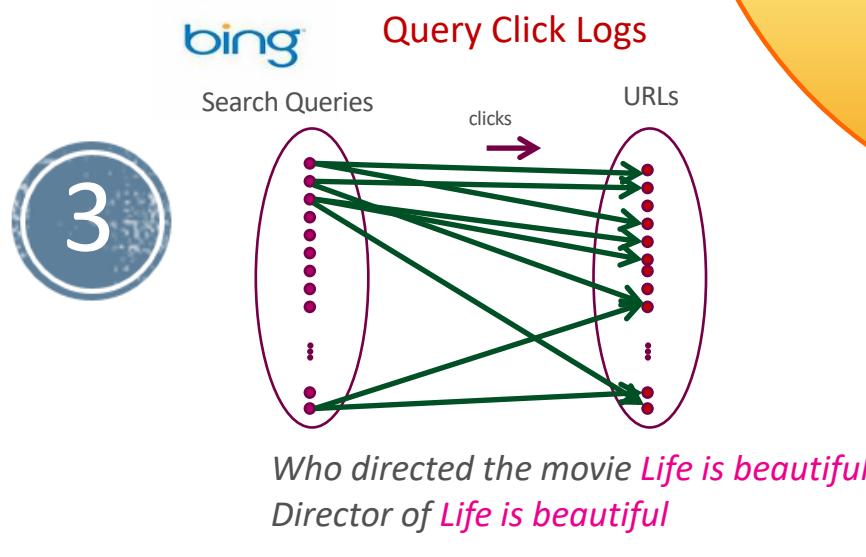
- Transfer labels from the knowledge graph to documents

More details in:

- Larry Heck, Dilek Hakkani-Tur, and Gokhan Tur, *Leveraging Knowledge Graphs for Web-Scale Unsupervised Semantic Parsing*, Proc. Interspeech, August 2013.

Linking Data to the Knowledge Graph

- Find queries whose users clicked on URLs found in steps 1 and 2
- Transfer labels from the graph to these queries

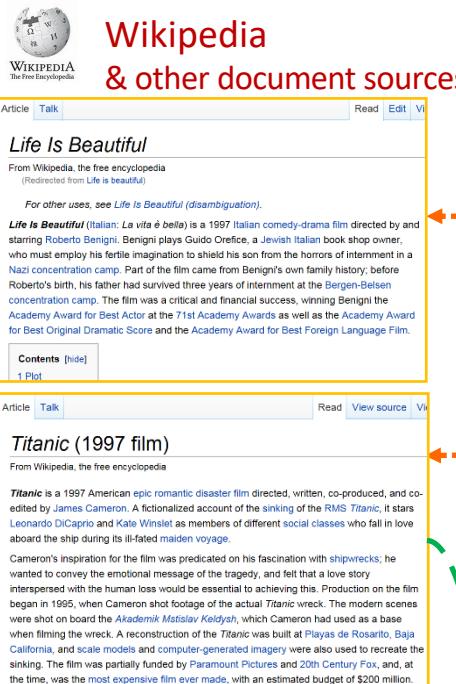


More details in:

- Gokhan Tur, Minwoo Jeong, Ye-Yi Wang, Dilek Hakkani-Tur, and Larry Heck, [Exploiting the Semantic Web for Unsupervised Natural Language Semantic Parsing](#), in *Proc. Interspeech*, September 2012.
- Dilek Hakkani-Tur, Larry Heck, and Gokhan Tur, [Using a Knowledge Graph and Query Click Logs for Unsupervised Learning of Relation Detection](#), IEEE ICASSP, May 2013.

Scaling Conversational Understanding Systems

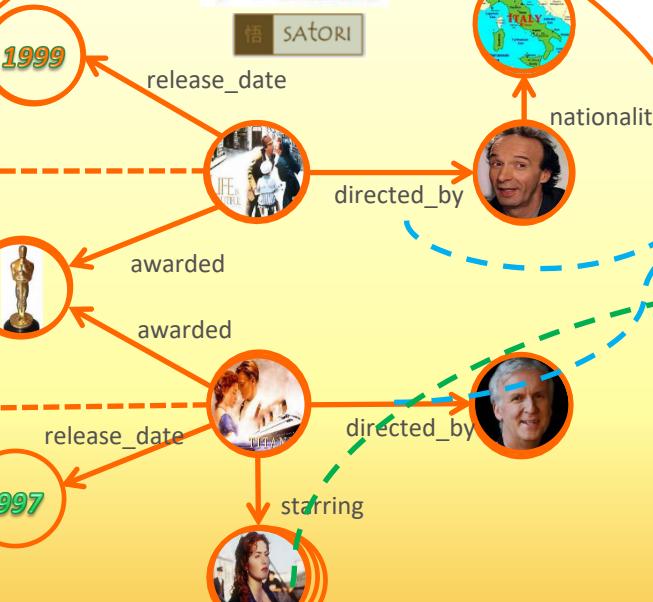
2



Knowledge Graph



SATORI



1



Web Search

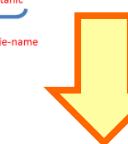
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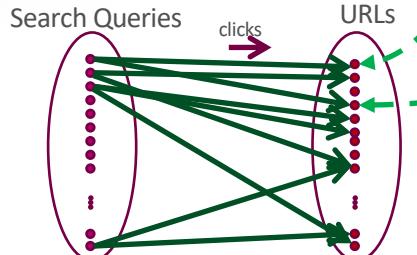
Italy's rubber-faced funnyman Roberto Benigni accomplishes ...
Life is beautiful is a 1997 Italian film which tells the story of a ...
Titanic is a 1997 American film directed by James Cameron...
James Cameron directed *Titanic* and he did the best job you...

Movie-name directed by Director-name
Director-name's Movie-name
Director-name directed Movie-name
...

James Cameron directed *Titanic*
James Cameron directed *Titanic*
Director-name directed Movie-name



bing Query Click Logs



Data & features for training
statistical CU models

Sample user utterances:	"Show me movies by Roberto Benigni"	"Who directed <i>Life is Beautiful</i> ?"
Corresponding relation on the knowledge graph		
User request in query language	<pre>SELECT ?movie { ?movie directed_by "Roberto Benigni". }</pre>	<pre>SELECT ?director { "Life is Beautiful" directed_by ?director. }</pre>
User request in logical form	$\lambda y. \exists x. x = "Roberto Benigni" \wedge \text{directed_by}(x,y)$	$\lambda y. \exists y. y = "Life is beautiful" \wedge \text{directed_by}(x,y)$

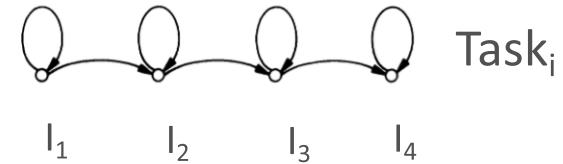
Conversational Context - Knowledge

KG-Bootstrapped Dialogue Modeling

Exploiting the semantic web for unsupervised spoken language understanding	Heck, Larry; Hakkani-Tür, Dilek;	IEEE Spoken Language Technology Workshop (2012)
Leveraging knowledge graphs for web-scale unsupervised semantic parsing	Heck, Larry; Hakkani-Tür, Dilek; Tur, Gokhan;	Interspeech (2013)
Using a knowledge graph and query click logs for unsupervised learning of relation detection	Hakkani-Tür, Dilek; Heck, Larry; Tur, Gokhan;	ICASSP (2013)
Exploiting the semantic web for unsupervised natural language semantic parsing	Tur, Gokhan; Jeong, Minwoo; Wang, Ye-Yi; Hakkani-Tür, Dilek; Heck, Larry;	Interspeech (2012)
Leveraging semantic web search and browse sessions for multi-turn spoken dialog systems	Wang, Lu; Heck, Larry; Hakkani-Tür, Dilek;	ICASSP (2014)
Extending domain coverage of language understanding systems via intent transfer between domains using knowledge graphs and search query click logs	El-Kahky, Ali; Liu, Xiaohu; Sarikaya, Ruhi; Tur, Gokhan; Hakkani-Tur, Dilek; Heck, Larry;	ICASSP (2014)
Probabilistic enrichment of knowledge graph entities for relation detection in conversational understanding	Hakkani-Tür, Dilek; Celikyilmaz, Asli; Heck, Larry; Tur, Gokhan; Zweig, Geoff;	Interspeech (2014)
Deep learning of knowledge graph embeddings for semantic parsing of Twitter dialogs	Heck, Larry; Huang, Hongzhao;	IEEE Global Conference on Signal and Information Processing (2014)
Leveraging deep neural networks and knowledge graphs for entity disambiguation	Huang, Hongzhao; Heck, Larry; Ji, Heng;	arXiv preprint arXiv:1504.07678

Conversational Context - Knowledge

KG-based Dialogue Modeling



Statistical methods for training dialogue managers is active area

Key Technical Challenge: amount of annotated dialogs required for training

Idea: leverage Web (IE) session data combined with Knowledge Graphs

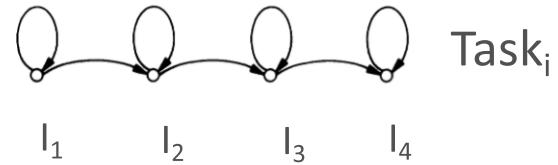
Web search & browse → Conversations/dialogue

Massive volume of interactions >1B+ queries/day, Millions of users

Coverage of user interactions is high (broad domains across the web)

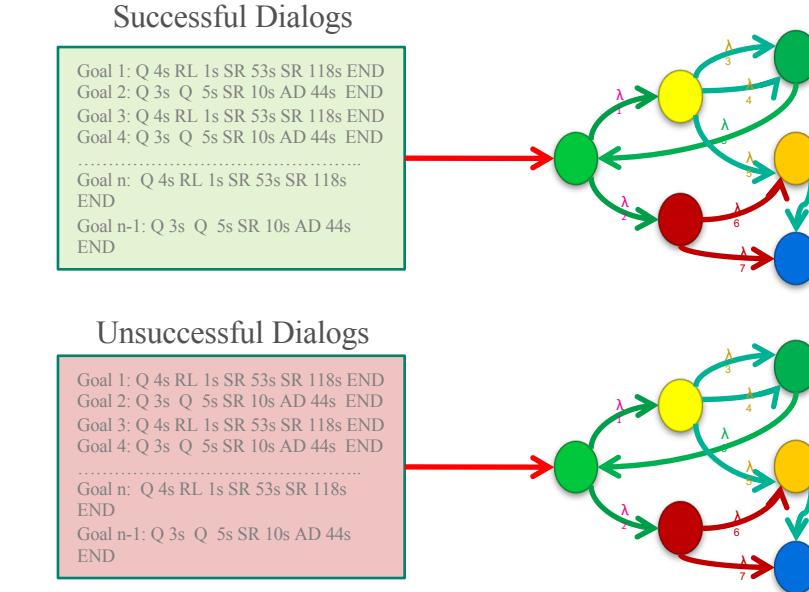
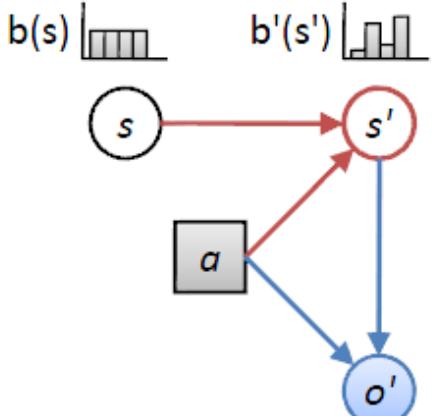
Conversational Context - Knowledge

KG-based Dialogue Modeling



New Approach

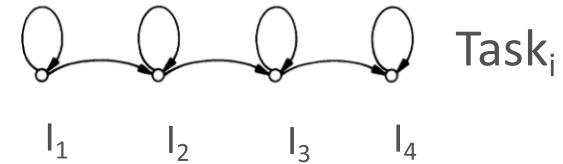
Step 1. *Learn task completion patterns from web* → IE sessions through KG



Step 2. *Bootstrap multi-turn spoken dialogue models from Knowledge Graph traversal paths*

Conversational Context - Knowledge

KG-based Dialogue Modeling



Results

Successfully learned ***conversational search and browse*** models from **IE sessions + KG**

Increased F-measures of semantic parsing by **> 18% (rel.)**

1st method to directly leverage **web browse patterns & knowledge graphs** to **bootstrap spoken dialogue models**

To dig deeper...

Lu Wang, Larry Heck, Dilek Hakkani-Tur, Leveraging Semantic Web Search and Browse Sessions for Multi-Turn Spoken Dialog Systems, *IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP)*, 2014

Conversational Context - Knowledge Deep Neural Knowledge Graphs

Exploiting the semantic web for unsupervised spoken language understanding	Heck, Larry; Hakkani-Tür, Dilek;	IEEE Spoken Language Technology Workshop (2012)
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Conversational Context - Knowledge

Deep learning from Knowledge Graphs

Transforming knowledge into deep neural representations

KGs enriched through data mining

- search queries-clicks, captions (snippets)
 - Wikipedia pages
- massive, structured, labeled data

Deep learning can discover compact semantic space of knowledge from enriched KGs

Knowledge Embeddings

Knowledge Embeddings provide computable vector-space of semantic relations in \mathbb{R}^N

$$P(e_i R_{ij} e_j)$$



Conversational Context - Knowledge

Deep learning from Knowledge Graphs

Bordes, Chopra, & Weston (2014)

- Embedding model for entity-bearing queries in open QA
- **Supervised training (WEBQUESTIONS), Small-Scale** subset of Freebase KG
- Matches previously reported accuracy without requiring lexicon, rules, POS taggers, parsers.

Yih, He, & Meek (2014)

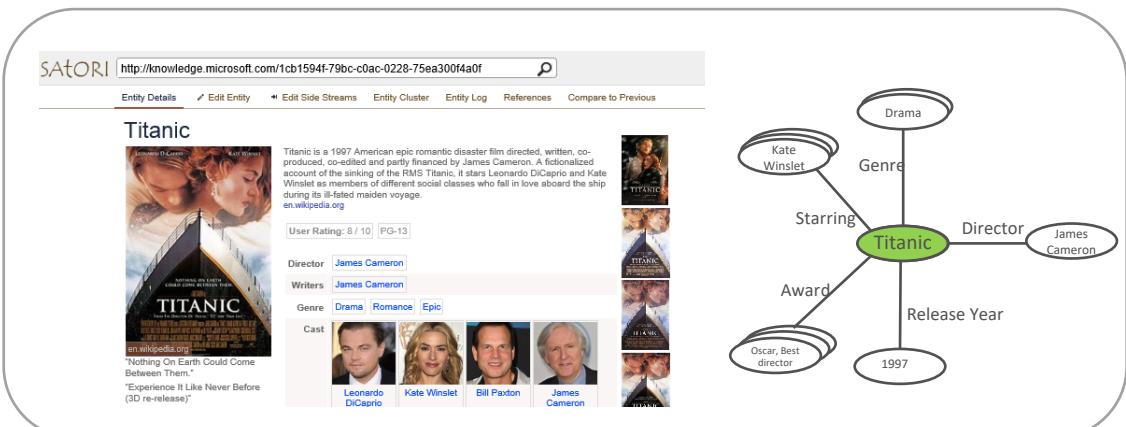
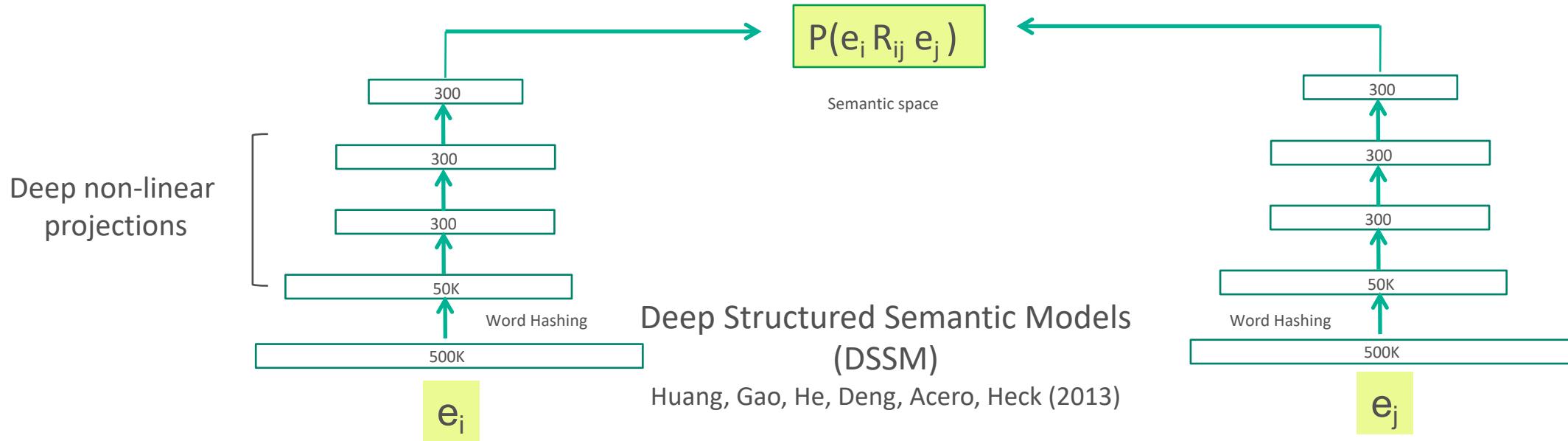
- DNN for single-relation QA
- **Supervised training, Small-Scale KG** tailored to PARALEX
- Achieves state-of-the-art performance (+7% F1)

Huang & Heck (2014)

- Embedding model for open domain semantic parsing
- **Unsupervised training (complete Wikipedia corpus), Large-Scale KG (Freebase)**
- State-of-the-art entity disambiguation for Twitter Wikification task (26% error rate reduction)

Conversational Context - Knowledge

Deep learning from Knowledge Graphs (Huang & Heck 2014)



Conversational Context - Knowledge

Experiment: Entity Disambiguation in Twitter

Disambiguate linkable **mentions** in Twitter tweets from a specific context to their referent **entities** in a Knowledge Graph

- A **mention**: a phrase referring to something in the world
- An **entity**: person, organization, object, event...

White House

From Wikipedia, the free encyclopedia

At a WH briefing here in Santiago, NSA spox Rhodes came with a litany of pushback on idea WH didn't consult with.

Santiago

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At a WH briefing here in Santiago, NSA spox Rhodes came with a litany of pushback on idea WH didn't consult with.

National Security Agency

From Wikipedia, the free encyclopedia
(Redirected from NSA)

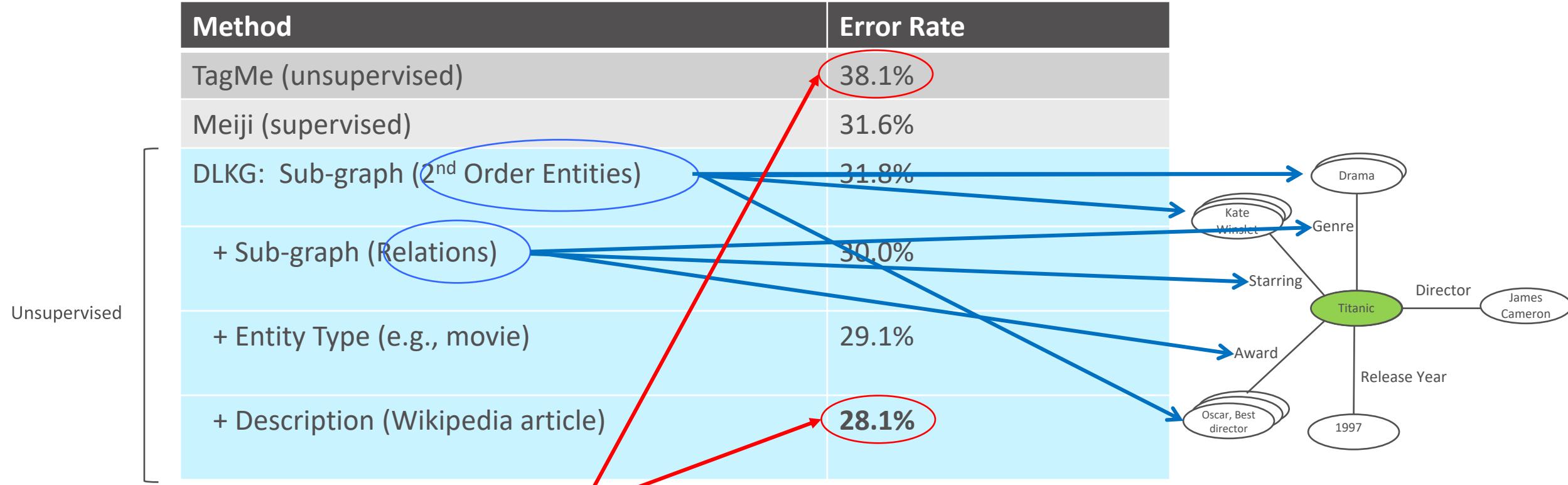
Conversational Context - Knowledge

Deep learning from Knowledge Graphs (Huang & Heck 2014)

Method	Error Rate
TagMe (unsupervised)	38.1%
Meiji (supervised)	31.6%

Conversational Context - Knowledge

Deep learning from Knowledge Graphs (Huang & Heck 2014)



For more details, see: Huang and Heck (2014)

Summary

Conversational Web

Taxonomy of the Conversational Web

- **Conversational Intents**
- **Conversational Context**

Conversational Intents

- Leverage “Web of Intents” click-stream for Conversational AI – massive (1B+ search queries-clicks/day) data with implicit semantics related to surface forms
- Bootstrap Personal Assistant NLU (domain, intent, slots)

Conversational Context

- Situated Dialogue (Multi-Modal, dialogue, geo, etc)
- Knowledge Context → *Push-button Conversational AI from a Knowledge (sub)Graph*
 - KGs to bootstrap Semantic Parsers (weak/unsupervised)
 - KGs for Relation Detection (weak/unsupervised)
 - KGs for Dialogue Modeling (weak/unsupervised)
 - Deep Neural KGs → convert discrete knowledge to continuous (embedded) form → combine with ML-based conversational AI



The Conversational Web

Larry Heck

CEO, Viv Labs
Head of Bixby North America

Thank You!