



# Keeping the Internet Open with An Open-Source Programmable Virtual Assistant

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Lab Sponsors: AVG, Google, HTC, Hitachi, ING Direct, Nokia, Samsung, Sony Ericsson

# Software Eats the World!

Marc Andreessen

Monopoly	Google search
Closed System	Apple app store
Loss of Privacy	Facebook social network

Who is going to eat these eaters?

# Virtual Assistants Eat the Internet



Virtual Assistant:

A Uniform, Personalized  
Language-based interface

Amazon Alexa, 25000 skills

Google assistant

Apple Siri

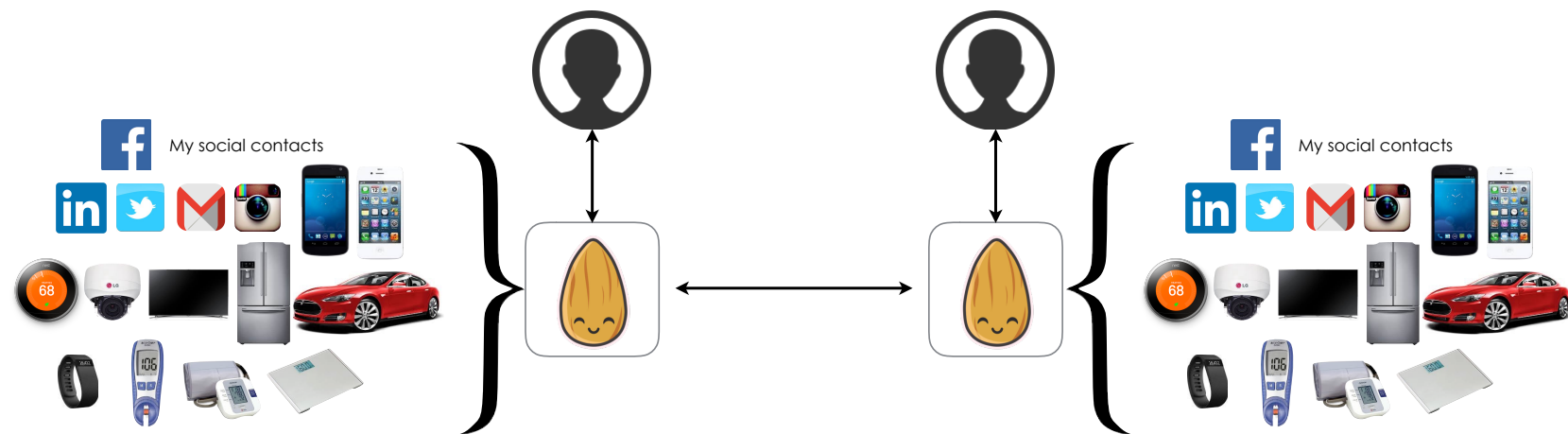
Closed System

Monopoly

Centralized

Loss of Privacy

# Almond: An Open-Source Decentralized Virtual Assistant



Open System

Open-Source

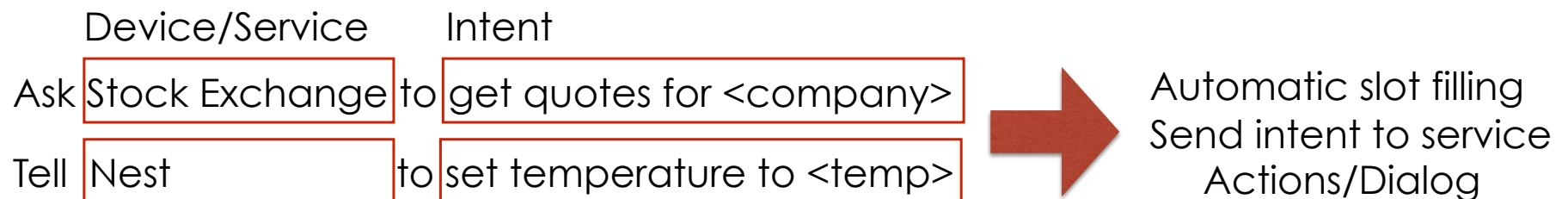
Decentralized

Privacy

End-User Programmable

# Today's Virtual Assistants

## VOICE INPUT



# End-User Programming

“When the price of Apple stock goes below \$150,  
get the balance of my checking account, if it is above \$20,000,  
send me an SMS with the price”.

- Not just simple commands / dialog dispatches
- A continuous event-driven program
- Connect different account & services together
- Parameter passing: returned results can be passed into functions
- Filters on values

# Key Technology: Semantic Parsing

Natural  
Language



Code  
(ThingTalk)

“When the price of Apple stock goes below \$150,  
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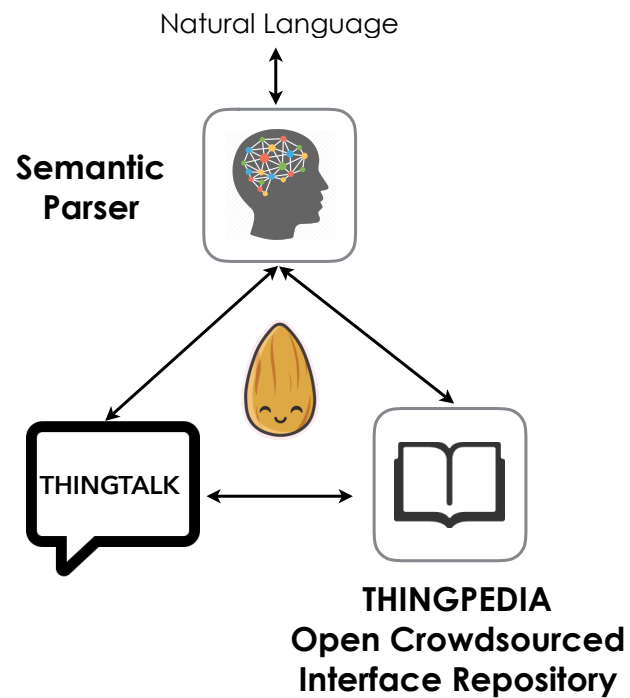
```
monitor @yahoofinance.stock_price(stock_id="aapl"),  
    ask_price < 150  
=> @bank.get_balance(), balance > 20000  
=> @phone.send_sms(body=ask_price)
```

# Power of End-User Programming

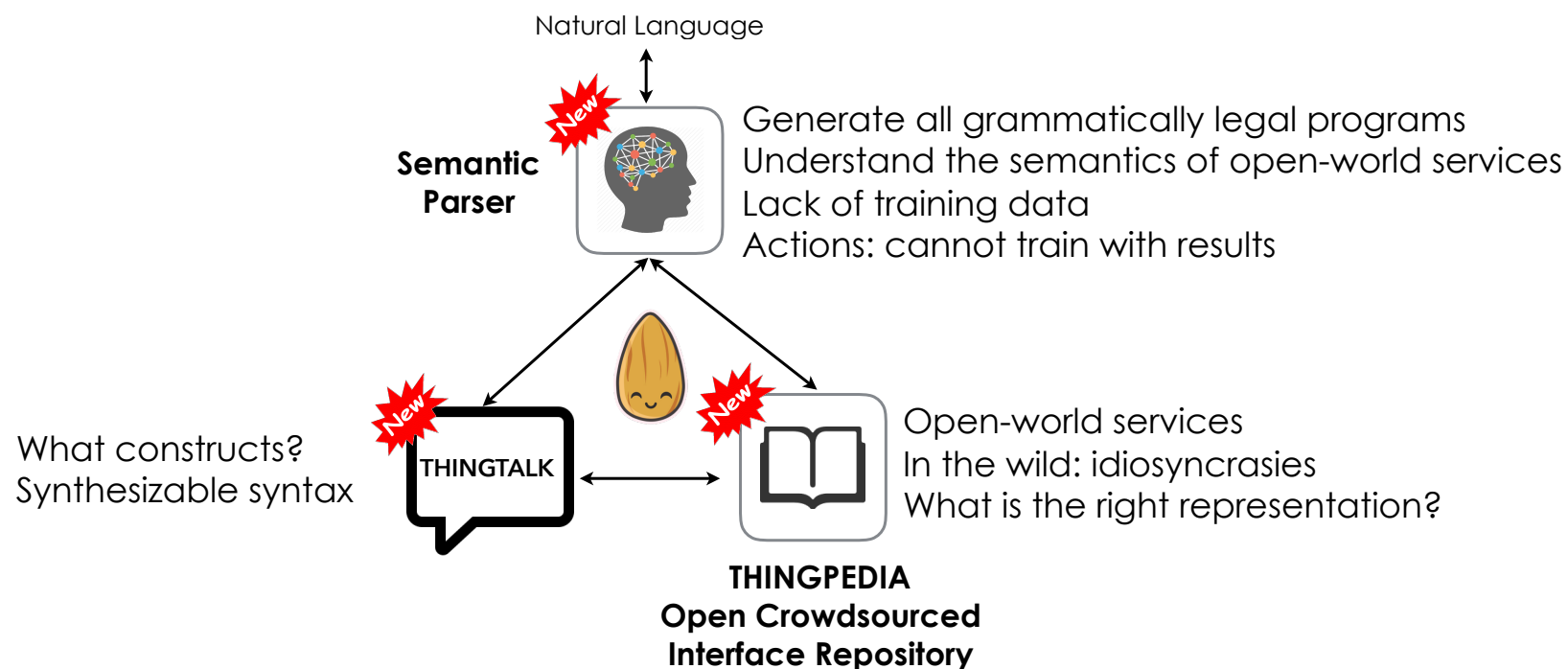
- Put the power of programming in the hands of the consumers
- Not limited to commercial “highly monetizable” services
- Personalized, long-tail function



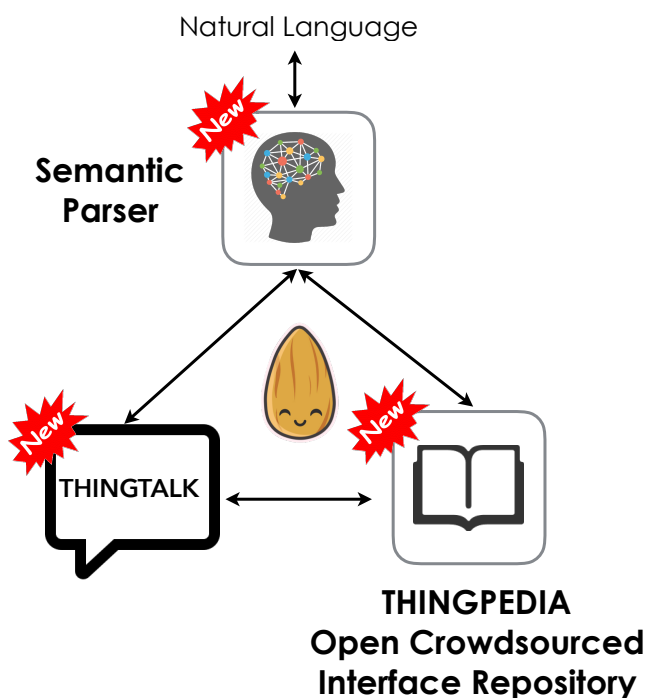
# Almond System Architecture



# Why is this Problem Hard?



# Strategy



- Focus: Representation of Thingpedia & ThingTalk
  - Support important future use cases
  - Must be amenable to semantic parsing
- Approach
  - An end-to-end system for sharing with privacy (2016-2017)
  - Revise (Q2 2018)
  - Crowdsource Thingpedia & open-source virtual assistant technology


Campagna, G. et al. "Almond: The Architecture of an Open Crowdsourced Privacy-Preserving Programmable Virtual Assistant", WWW Conference, April 2017



# Thingpedia: Encyclopedia of Things



Currently:  
45 devices  
177 functions

 Natural Language	Code
<b>WHEN</b> @Stanford tweets	Monitor (@home_timeline(), ...) author=="Stanford")
<b>GET</b> tweets matching "#Cardinal"	search(...), contains (hashtag, ...)
<b>DO</b> tweet "Stanford won!"	post (status)

## ALMOND

### 📧 Examples

Tweet the latest NASA Astronomy Picture of the Day  
Auto reply to my emails  
Set my phone to vibrate every day at 9 am  
Turn on my TV if there is a person in the room  
Translate Washington Post headlines to "Chinese"  
Post my new Instagram pictures on Twitter  
get a snapshot from my security camera every hour  
Play some video from YouTube on my TV  
Send me a daily cat picture

### 🚲 Almond Bike Market

WHEN: monitor second hand bike posts  
WHEN: monitor bike posts of brand \_\_  
WHEN: monitor bikes for \_\_  
GET: search second hand bikes  
GET: search bike posts of brand \_\_  
GET: search bikes for \_\_  
DO: post on almond bike market  
DO: post a bike for \_\_ dollars on almond bike market

### ❤️ Almond Dates

WHEN: monitor date posts on almond dates  
WHEN: monitor date posts about \_\_  
GET: search partners on almond dates  
GET: search \_\_ partners  
DO: post on almond dates  
DO: post on almond dates to find partners for \_\_

### 🔍 Bing Search

GET: search \_\_ on bing  
GET: search \_\_ images on bing  
GET: search images matching \_\_ with size \_\_x\_\_ on bing

### 🔊 Bluetooth Speaker

DO: set my speaker as default  
DO: play music on my speaker  
DO: increase volume on my speaker  
DO: decrease volume on my speaker  
DO: set volume on my speaker to \_\_%

### 📏 BodyTrace Scale

WHEN: my weight updates

### 💧 Dropbox

GET: my dropbox quota  
GET: file list in folder \_\_ on dropbox  
GET: file named \_\_ on dropbox  
DO: move file \_\_ to \_\_ in dropbox  
DO: rename file \_\_ in dropbox  
DO: create a folder with name \_\_ in my dropbox

### 📘 Facebook

DO: post on facebook saying \_\_  
DO: post a picture on facebook  
DO: post a picture on facebook with caption \_\_

### 📷 Giphy

GET: a ranD0M gif from giphy  
GET: a gif with tag \_\_ from giphy

### 🐙 Github

WHEN: a new issue opened in github repository \_\_  
WHEN: \_\_ opens an issue on github  
WHEN: user \_\_ opens an issue in github repository \_\_  
WHEN: there is a new commit for github repository \_\_  
WHEN: user \_\_ commits in github repository \_\_  
WHEN: a new milestone is created in github repository \_\_  
WHEN: user \_\_ create a new milestone in github repository \_\_

WHEN: there is a new comment in github repository \_\_  
WHEN: user \_\_ comments on some issue in repository \_\_  
WHEN: there is a new comment on issue \_\_ in repository \_\_  
DO: add email \_\_ to my github account  
DO: comment on issue \_\_ in github repository \_\_

### 📧 Gmail

WHEN: receive an email on gmail  
WHEN: receive an email from \_\_ on gmail  
WHEN: receive an email marked as important  
WHEN: receive an email marked as important from \_\_  
WHEN: receive an email in category primary  
WHEN: receive an email from \_\_ in category primary  
GET: the latest email  
GET: the latest email with label \_\_  
GET: the latest email from \_\_  
GET: the latest email with subject \_\_  
DO: send an email to \_\_ with subject \_\_ with message \_\_  
DO: send a picture to \_\_ with subject \_\_

### 📁 Google Drive

WHEN: a new file or folder is created on google drive  
DO: create a new file with name \_\_ on google drive

### 📅 Holidays Calendar

WHEN: it's an holiday in the uk  
WHEN: it's an holiday in the us  
GET: the next uk holiday  
GET: the next us holiday

### 📅 iCalendar Events

WHEN: an event on my calendar begins  
WHEN: an event on my calendar at location \_\_ begins  
WHEN: an event on my calendar organized by \_\_ begins  
GET: list my calendar events  
GET: my calendar events organized by \_\_  
GET: my calendar events at \_\_

### 📄 Imgflip Meme Generator

GET: all meme templates  
GET: meme template named \_\_  
GET: generate meme on template \_\_ with text \_\_ at the top and text \_\_ at the bottom

### 📷 Instagram

WHEN: i upload a picture on instagram  
WHEN: i upload a picture with filter \_\_ on instagram  
GET: my recent instagram pictures  
GET: \_\_ many recent instagram pictures  
GET: my instagram pictures with filter \_\_

### 🏃 Jawbone UP

WHEN: my steps on activity tracker updates  
WHEN: i walked for \_\_ steps  
WHEN: i walked for \_\_ distance  
WHEN: my weight updates on my fitness tracker  
WHEN: my weight is \_\_ on my fitness tracker  
WHEN: my bmi is \_\_ on my fitness tracker  
WHEN: my body fat is \_\_ on my fitness tracker  
WHEN: my heart rate updates  
WHEN: my heart rate is \_\_  
WHEN: my sleep status updates on my sleep tracker  
WHEN: i sleep for \_\_ time

### 📺 LG WebOS TV

DO: turn \_\_ my lg tv  
DO: raise the volume of my lg tv  
DO: lower the volume of my lg tv  
DO: set the volume of my lg tv to \_\_  
DO: mute my lg tv

DO: unmute my lg tv  
DO: play link \_\_ on my lg tv

### 🌐 LinkedIn

GET: my linkedin profile  
DO: post \_\_ on linkedin

### 🔧 Miscellaneous Interfaces

WHEN: it's \_\_ o'clock every day  
GET: current time  
GET: current date  
GET: give me a random number  
GET: give me a random number between \_\_ and \_\_  
DO: debug log \_\_  
DO: send me a message \_\_

### 🚀 NASA Daily

WHEN: an asteroid passes close to earth  
GET: nasa's astronomy picture of the day  
GET: a picture from curiosity rover  
GET: \_\_ many pictures from curiosity rover  
GET: a picture from curiosity rover taken on \_\_

### 🏠 Nest

WHEN: the temperature on my thermostat updates  
WHEN: the humidity on my thermostat updates  
WHEN: there is a new event detected on my security camera  
WHEN: my security camera detects something and has person is \_\_  
WHEN: my security camera detects something and has motion is \_\_  
WHEN: my security camera detects something and has sound is \_\_  
GET: the temperature on my thermostat  
GET: the humidity on my thermostat  
GET: the state of my hvac  
GET: my security camera live feed  
GET: me a snapshot of my security camera  
DO: set temperature to \_\_ on my thermostat  
DO: set my temperature between \_\_ and \_\_ on my thermostat  
DO: set my hvac to \_\_  
DO: turn \_\_ my security camera

### 📧 Omlet

WHEN: i receive a message on omlet  
WHEN: i receive a message on omlet in feed \_\_  
WHEN: i receive a \_\_ message on omlet  
DO: send an omlet to \_\_ saying \_\_  
DO: send a picture on omlet to \_\_ with caption \_\_

### 📁 OneDrive

WHEN: a new file is created on onedrive  
WHEN: a file is modified on onedrive  
WHEN: file \_\_ on onedrive is modified  
DO: create a new file on onedrive named \_\_ containing \_\_  
DO: delete \_\_ from my onedrive  
DO: rename \_\_ to \_\_ on my onedrive  
DO: upload a picture to onedrive with name \_\_

### 🌸 Parklon Iris Warm Water Mat

DO: turn \_\_ my heatpad  
DO: turn \_\_ my parklon heatpad

### 📄 PhD Comics

WHEN: there is a new post on phd comics

### 💡 Philips Hue

DO: turn \_\_ my lightbulb  
DO: disco lights  
DO: flash the lightbulb

### 📞 Phone Companion

WHEN: my location changes  
WHEN: i receive a sms

WHEN: i receive a sms from \_\_  
DO: show a popup with title \_\_ and body \_\_  
DO: send an sms to \_\_ saying \_\_  
DO: set my phone to \_\_  
DO: call number \_\_  
DO: call 911

### 📄 Reddit Frontpage

WHEN: reddit front page updates  
WHEN: a new post in category \_\_ reaches reddit front page  
WHEN: a new post from user \_\_ reaches reddit front page

### 📡 RSS Feed

WHEN: there is a new post on rss feed

### 🔧 Slack

WHEN: i receive a message on slack  
WHEN: i receive a message from \_\_ on slack  
WHEN: i receive a message in channel \_\_ on slack  
DO: send a message on slack to \_\_ saying \_\_  
DO: set the purpose for channel \_\_ to \_\_ on slack  
DO: set the topic for channel \_\_ to \_\_ on slack  
DO: set me as \_\_ on slack  
DO: send a picture on slack to \_\_ saying \_\_

### 🏈 SportRadar

WHEN: nba team \_\_ plays  
WHEN: nba team \_\_ plays against \_\_  
WHEN: nba team \_\_ plays and the game is \_\_  
WHEN: nba team \_\_ a game  
WHEN: eu soccer team \_\_ plays  
WHEN: eu soccer team \_\_ plays against \_\_  
WHEN: eu soccer team \_\_ plays and the game is \_\_  
WHEN: eu soccer team \_\_ a game  
WHEN: us soccer team \_\_ plays  
WHEN: us soccer team \_\_ plays against \_\_  
WHEN: us soccer team \_\_ plays and the game is \_\_  
WHEN: us soccer team \_\_ a game  
WHEN: monitor eu soccer games of tournament \_\_  
WHEN: monitor us soccer games of tournament \_\_  
WHEN: mlb team \_\_ plays  
WHEN: mlb team \_\_ plays against \_\_  
WHEN: mlb team \_\_ plays and the game is \_\_  
WHEN: mlb team \_\_ a game .  
WHEN: ncaa mens basketball team \_\_ plays  
WHEN: ncaa mens basketball team \_\_ plays against \_\_  
WHEN: ncaa mens basketball team \_\_ plays and the game is \_\_  
WHEN: ncaa mens basketball team \_\_ a game .  
WHEN: ncaafb team \_\_ plays  
WHEN: ncaafb team \_\_ plays against \_\_  
WHEN: ncaafb team \_\_ plays and the game is \_\_  
WHEN: ncaafb team \_\_ a game

### 🐾 The Cat API

GET: a cat picture  
GET: \_\_ many cat pictures

### 📰 The Wall Street Journal

WHEN: there is a new article in wsj opinions section  
WHEN: there is a new article in wsj world news section  
WHEN: there is a new article in wsj us business section  
WHEN: there is a new article in wsj market news section  
WHEN: there is a new article in wsj technology section  
WHEN: there is a new article in wsj lifestyle section

### 📰 The Washington Post

WHEN: there is a new article in washington post \_\_ section  
WHEN: there is a new blog post in washington post \_\_ blog

### 📄 Tumblr

WHEN: there is a new post in blog \_\_ on tumblr

WHEN: there is a new picture uploaded in blog \_\_ on tumblr  
DO: post on tumblr with title \_\_ and body \_\_  
DO: post \_\_ on tumblr  
DO: post a picture with caption \_\_ on tumblr

### 🐦 Twitter

WHEN: someone i follow tweets  
WHEN: user \_\_ tweets  
WHEN: someone replies to user \_\_ on twitter  
WHEN: i receive a direct message on twitter  
WHEN: i receive a direct message from \_\_ on twitter  
WHEN: i tweet  
WHEN: i reply to \_\_ on twitter  
GET: search for \_\_ on twitter  
GET: \_\_ many recent tweets matching \_\_  
GET: recent tweets from \_\_  
GET: recent tweets in reply to \_\_ matching \_\_  
GET: recent tweets in reply to \_\_ matching \_\_  
GET: search for tweets with hashtag \_\_ on twitter  
GET: \_\_ many recent tweets with hashtag \_\_  
GET: tweets from \_\_ with hashtag \_\_  
GET: tweets with hashtag \_\_ in reply to \_\_  
DO: tweet \_\_  
DO: send a dm on twitter to \_\_ saying \_\_  
DO: tweet a picture with caption \_\_  
DO: follow user \_\_ on twitter  
DO: unfollow user \_\_ on twitter

### 🚗 Uber

GET: time estimate for uber  
GET: give me a price estimate for uber from \_\_ to \_\_

### 🌤️ Weather

WHEN: it's \_\_ at location \_\_  
WHEN: monitor weather at \_\_  
GET: sunrise and sunset for location \_\_  
GET: sunrise and sunset for location \_\_ on date \_\_  
GET: moon phase for location \_\_  
GET: moon phase for location \_\_ on date \_\_  
GET: the weather in \_\_

### 🏀 XKCD

WHEN: a new xkcd is out  
WHEN: a new xkcd is out in the what-if section  
GET: the latest xkcd  
GET: the xkcd number \_\_  
GET: a random xkcd

### 📈 Yahoo Finance

WHEN: the stock price of \_\_ changes  
WHEN: stock dividends for \_\_ changes

### ↔️ Yandex Translate

GET: translate \_\_ to \_\_ with yandex.  
GET: translate \_\_ from \_\_ to \_\_ with yandex  
GET: translate \_\_  
GET: translate something to \_\_  
GET: translate with yandex from \_\_ to \_\_  
GET: detect the language of \_\_

### 📺 Youtube

WHEN: there is a new video from youtube channels i follow  
WHEN: there is a new video from youtube channel \_\_  
GET: list channels in category \_\_ on youtube  
GET: list channels i am subscribed to on youtube  
GET: search \_\_ channels on youtube  
GET: search a \_\_ video on youtube  
GET: search a video from \_\_ matching \_\_ on youtube  
GET: search \_\_ many videos matching \_\_ on youtube

# ThingTalk Compound Construct

**WHEN** [FILTERS] → **GET** [FILTERS] → **DO**

**FILTERS:** =, <, >, <=, >=, contains, starts with, ends with

When my alarm goes off, open my blinds

Get my tweets and save them to Dropbox

Every day at 9 am, get my tweets and send them to Dropbox

When I receive an email from my advisor then send the message on SMS

# Real Natural Language Input

When I tweet, share the text on LinkedIn

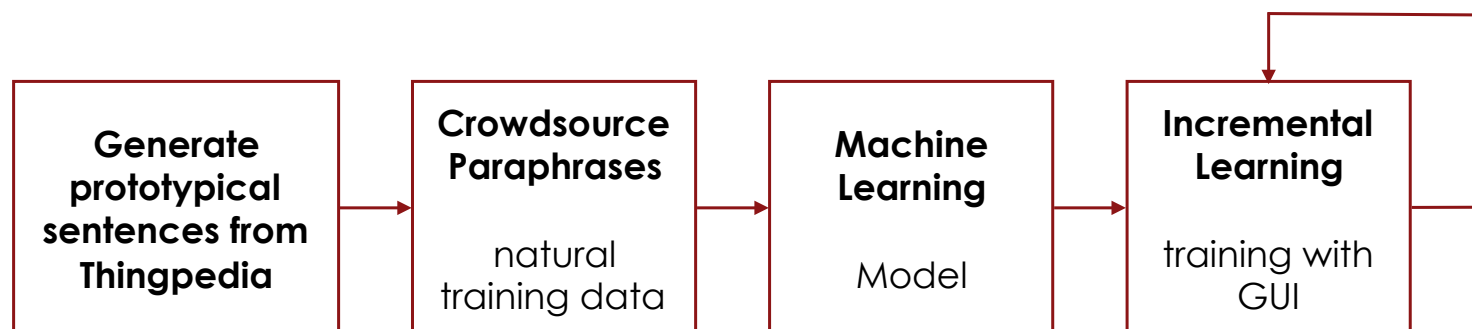
Share my tweets on my LinkedIn

Whenever I tweet, post the same message on LinkedIn

Post all my tweets on LinkedIn

# Bootstrapping the Machine Learner

There is no pre-existing data corpus





# Neural Network: Seq2seq with Attention

Natural Language

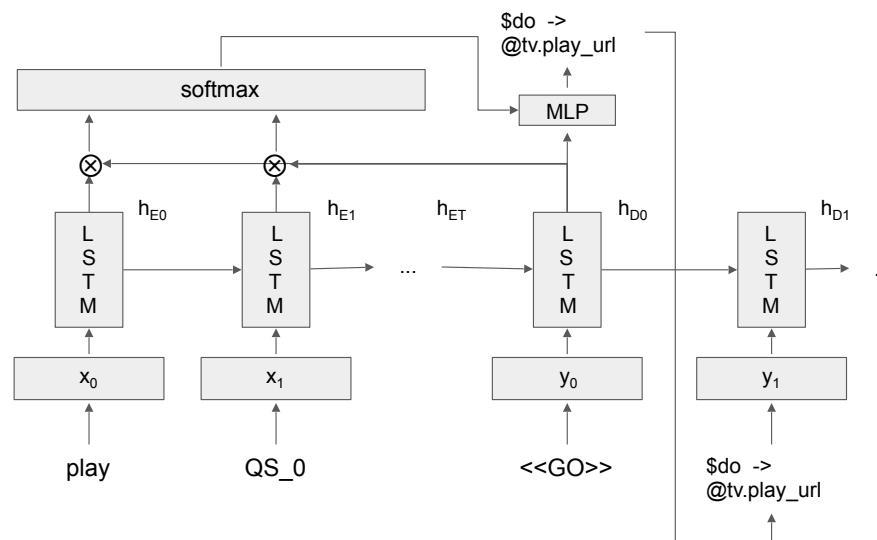
play QS\_0 from Youtube on my TV

Bottom-up grammar reductions

$\$get \rightarrow @youtube.search\_video$   
 $\$const\_String \rightarrow QS\_0$   
 $\$const\_param \rightarrow query = \$const\_String$   
 $\$get \rightarrow \$get \$const\_param$   
 $\$do \rightarrow @tv.play\_url$   
 $\$rule \rightarrow now \Rightarrow \$get \Rightarrow \$do$   
 $\$out\_param \rightarrow video\_url$   
 $\$param\_passing \rightarrow url = video\_url$   
 $\$rule \rightarrow \$rule\ on\ \$param\_passing$   
 $\$input \rightarrow \$rule$

ThingTalk code

$@youtube.search\_video\ (query = QS\_0)$   
 $\Rightarrow @tv.play\_url\ (url = video\_url)$

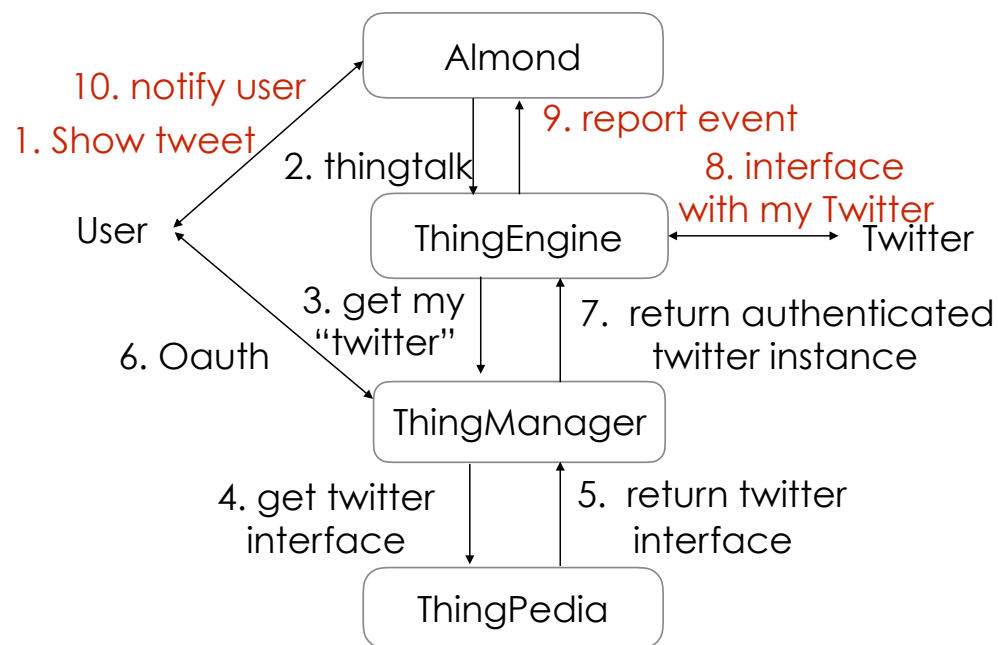


# Execution of ThingTalk

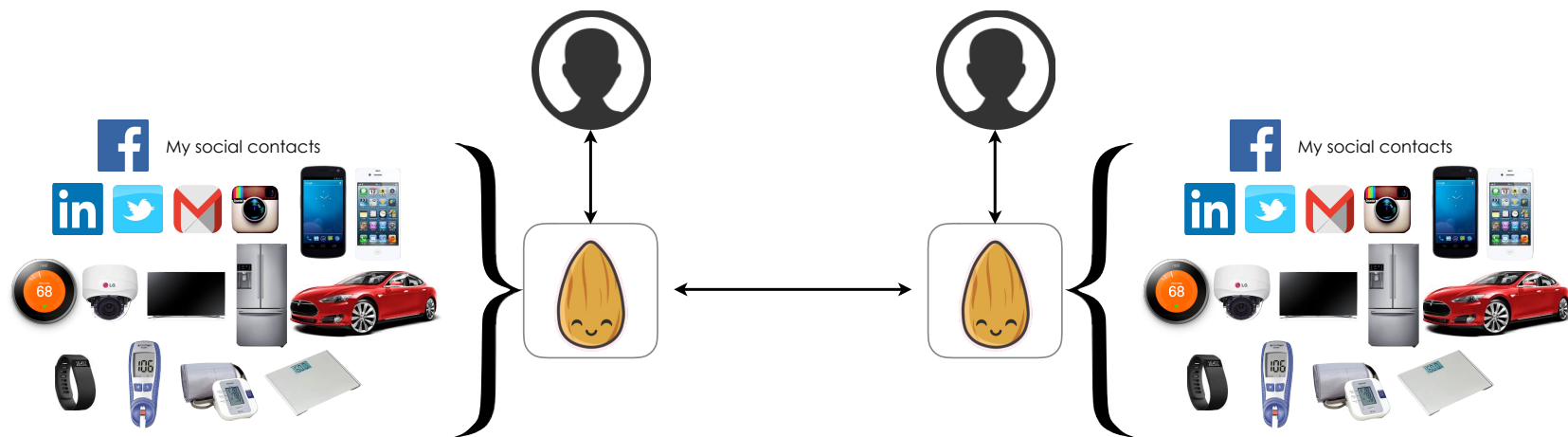
Show me tweets with hashtag #Stanford



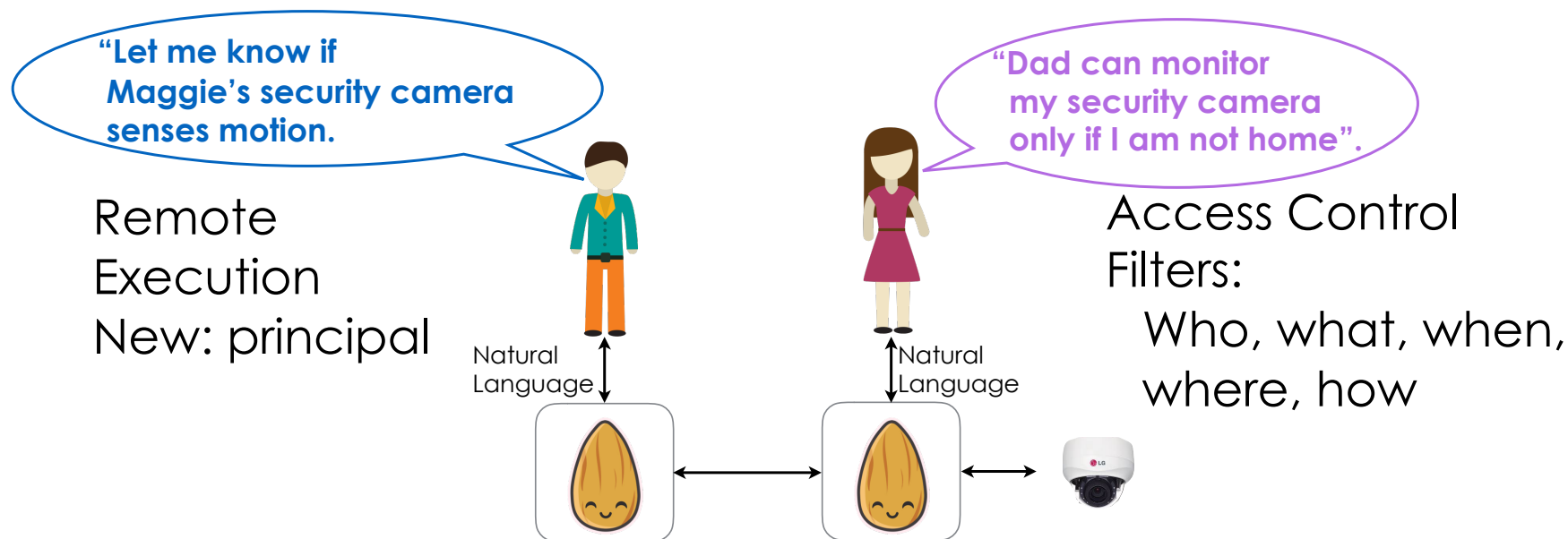
Monitor (@com.twitter.home\_timeline(),  
contains(hashtags, "Stanford"))  
⇒ notify



# Sharing Without a Third-Party

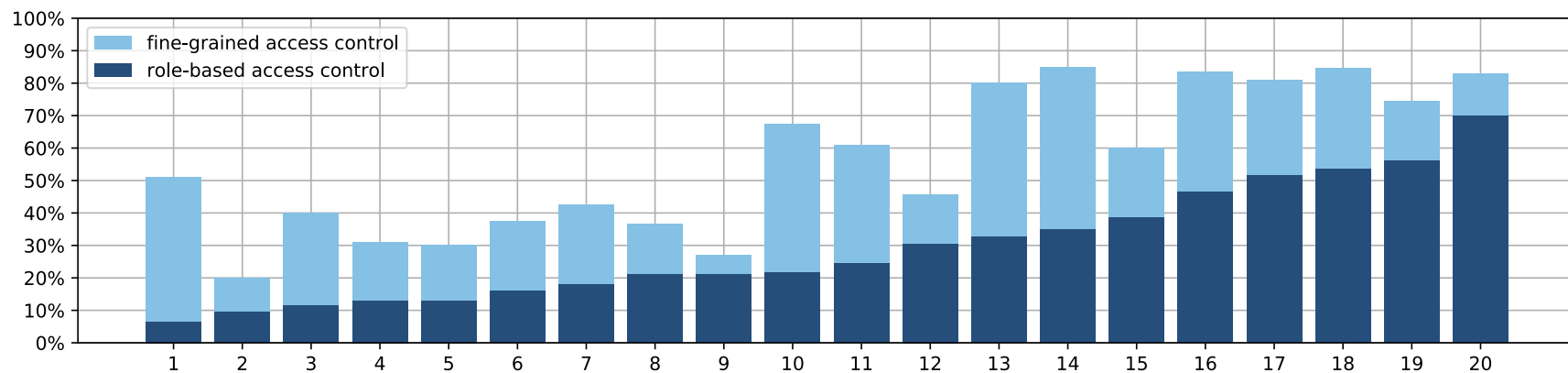


# Sharing with Access Control



# Is Access Control Needed?

% 200 people finding sharing scenario comfortable

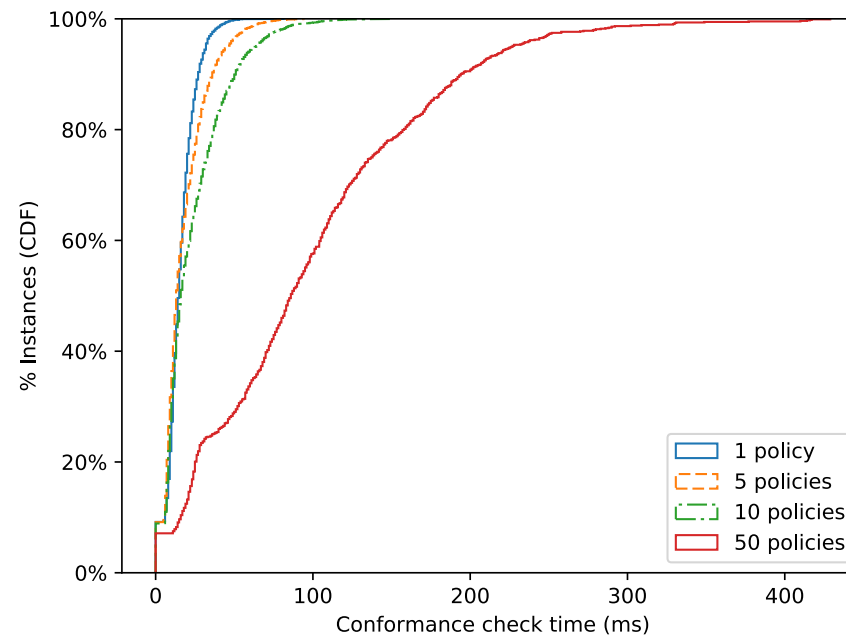


(#10) Sharing scenario: Allow your friends to have access to your cloud drive to view/download photos

Access control: Only photos with their faces on them; only photos in a specific folder

# Access Control Conformance = Satisfiability Modulo Theories

It's fast enough



# Summary

## **Almond: An Open-source, Privacy-preserving, End-user programmable virtual assistant**

- Virtual assistants will eat the internet
- User-programmable with privacy
  - Long-tail, personal preference
  - Sharing existing services with full user control and privacy

# Closing Remarks



Remember AoL?

