Adobe® Story and Creative Suite 5 – New Semantic Technologies for the Motion Picture and Video Industry

Semantic Technology Conference
June 24, 2010

Walter W. Chang
Principal Computer Scientist
Adobe Advanced Technology Labs

Marci Meingast
Senior Computer Scientist
Adobe Dynamic Media Organization

Swapnil Gupta
Software Quality Engineer
Adobe Dynamic Media Organization

Adobe Systems, Inc.
Overview

- Background
- Challenging problems for semantic technologies in the Motion Picture and Video Industry
- Adobe Story and Creative Suite 5 semantic features
- Knowledge representation and hybrid ontologies
- Strategies for ontology mapping
- Strategies for ontology refinement & evolution
- Future directions
Background

- Walter Chang - Principal Computer Scientist
  Systems Technology Group
  Adobe’s Advanced Technology Lab

- Marci Meingast – Video Technology Research Scientist
  Digital Media Organization, Adobe Systems
  PhD, EECS/Computer Vision UC Berkeley

- Swapnil Gupta – Software Quality Engineer
  Adobe Story Engineering
  Digital Media Organization, Adobe Systems
  B.Tech, CS and Engineering, HBTI Kanpur
Key semantic challenge: Understand the content

- Scene description
- Set elements
- Characters
- Props
- Costume
- Makeup
- Lighting
- Camera shots
- Action descriptions..
Script content & context spans a broad spectrum
Taxonomies exist for multimodal data types

Video Content
- Text Metadata
  - Production Design
    - Set design
    - Storyboard
  - Spec & Shooting
    - Scripts
- Audio Metadata
  - Transcripts
  - Non-dialog features
    - Automatic Speech-To-Text (STT)
    - Music
    - Ambient noise
    - Applause
    - Laughter
    - Special EFX
- Video Metadata
  - Scene Changes
  - Shot Detection
  - Face/Object entities
  - Transitions
  - Generic Sound Library
  - Custom EFX
  - Dialog/Narrative
    - Character dialog
    - Character descriptions
    - Narratives
  - Action Descriptions
  - Scene List
    - Scene title
    - Scene attributes
    - Scene description
  - Shot List
  - Scene List
  - Scene title
  - Scene attributes
  - Scene description
  - Shot List
  - Dialog/Narrative
    - Character dialog
    - Character descriptions
    - Narratives
  - Action Descriptions
Approach: Capture and unlock script semantics

Hollywood Movie Spec. Script

- Scene heading
- Location
- Time
- Scene description
- Set objects...
- Character name
- Character dialog
- Action description
- People
- Places
- Props...
FSM Model of Hollywood Spec. Script
What is the full semantic analysis workflow?

- Create or Capture Hollywood Spec. Scripts
- Structure or parse existing script structure
- Extract and preprocess NL text
How are scripts processed by Adobe Story?

1. A set of text extraction filters obtains layout-preserved reading-order text from the spec. script.
2. A two-pass process is used:
   (2a) Pass 1: builds a statistical model of the document layout and analyzes the model.
   (2b) Pass 2: reads script lines, tokenizes lines, then invokes the Parser and Finite State Machine (FSM) to analyze candidate line elements.
3. Element symbol tables are used to identify domain-specific keywords.
4. Script element rules are used to match complex element patterns (e.g., numbered Scene Headings).
5. Finite State Machine implements the script element state transition model to determine how to extract specific element types.
6. Script element type-specific logic is used to extract each script element and all associated attributes.
7. Multiformat output tag generators are used for each type-specific script element to create text, XML, and database records for each element.
8. Adobe Story Script
9. XML
10. The key output of this invention is the Adobe Story XML representation of the input spec. script.
What is the full semantic analysis workflow?

- Create or Capture Hollywood Spec. Scripts
- Structure or parse existing script structure
- Extract and preprocess NL text
- Perform text analysis and tagging and Named Entity Resolution
- Categorize entities using lower ontology (LO)
- Contextualize & map LO entries to upper ontology (UO)
- Save semantic entities and statements into RDF triplestore
- Return semantic autotag metadata to Adobe Story client
- Optionally time sync script metadata to video content
How are movie scripts auto-tagged for metadata?

Adobe Story
Client Script Application

Adobe Script Services

What is the script time synchronization workflow?

- Generate Custom Language Model for Audio
- Generate Speech-to-Text (STT) Transcript from Audio Track
- Align STT transcript to dialog words in Spec. Script using
  - Word ngram model
- Interpolate timecodes for unmatched word entries in alignment matrix
- Interpolate timecodes for non-dialog words in Spec. Script (all non-dialog entities)
- Publish or save all timecoded script entities to RDF-Triplestore
How are scripts time-synchronized to video?
How are scripts time-synchronized to video?

File: IJTLGC
Size: n = 7000
m = 5000
Raw: O(n x m) = 40 min.
Stopword filtered: = 4 min.

Partitioned DP:
O(n1 x m1) +
O(n2 x m2) +
O(n3 x m3) +
... +
O(nP x mP)

Partitioned DP: = 16 sec.
ScriptAlign feature in CS5 Premiere Pro
How do ontologies help us categorize entities?

- Upper Ontology (UO) specific to film/video industry
- Lower Ontologies (LOs) consist of:
  - Generic (commonplace) object ontologies (e.g. for props)
  - Domain-specific and specialized ontologies (e.g. for sound EFX)
  - Functional and taxonomic aspects (e.g., vehicle vs. container)
- Adobe Story Ontology Approach
  - Identify operational roles of production personnel
  - Determine metadata needs for given role
  - Use roles to contextualize LO and UO
Production Depts. Require Different Ontologies
Roles Within Depts. May Need Sub-ontologies

The Art Department

The Properties Department
The Properties Department forms part of the Art Department, and its members are therefore responsible to the Production Designer.

Property Master
Oversees and is responsible for, the procurement or production, inventory, care and maintenance of all props associated with productions, ensuring that they are available on time, and within budgetary requirements.

Prop Maker
Prop Makers work in the Properties Departments of feature films, making any props that are not being bought in, or hired.

Armourer
Armourers are responsible for the transport, storage and use of all weaponry and firearms on film sets.

Greensman
Greensmen are responsible for procuring, placing, and maintaining any vegetation (foliage and other greenery) on film sets.

Props Storeman
Props Storemen organize the transport, installation, storage and return of all props for film productions.

Dressing Props
Dressing Props personnel install props on sets and locations before film crews arrive to shoot scenes.

Standby Props
Standby Props work on set during the filming of a scene, overseeing the use of props, and monitoring their continuity.
Lower Ontology to Upper Ontology Mapping Problem

- Roles define UO – relatively simple structure (vs. LO.)
- Existing LOs provide many useful categorizations
  - Given: a script entity \( x \), we wish to tag \( x \) by using LO, an ontology-based classification mechanism.
  - Given: \( \text{LO}_i : \text{Classify}_i(x) = c_{x[i]} \)
  - Goal: \( \text{UO}_j : \text{Classify}_j(c_{x[i]}) = C_{x[j]} \)
  - Need: \( \text{Map}(c[1],..,c[i],..,c[n]) \Rightarrow (C[1],..,C[i],..,C[n]) \text{ in } \text{UO}_j \)

Map(LO) forms new sub-ontologies in UO e.g., “Greenery”
Methods for mapping LOs to UO in Adobe Story

- For given entity term x, apply LO classification
  - Find all LO terms $t_{[k]}$ for entity x (i.e., $k=1..M$ “senses of x”)
  - For each $t_{[k]}$, select highest probability hierarchy path(s) relative to Cx in UO

$$x = \begin{pmatrix}
t[1] \\
t[2] \\
\vdots \\
t[k] \\
\vdots \\
t[N-1] \\
t[N]
\end{pmatrix}$$
Adobe Story Upper to Lower Ontology Mapping

~ 50 Story UO Categories

~ 300 Internal LO Categories

~ 82000 Synonym Set Categories

LO Lexicographical Ontology Terms
~ 119,000 Noun terms
~ 11,500 Verb terms
~ 21,400 Adjective terms
Script capture, authoring, tagging, & collaboration

Adobe Story - Movie Script Capture and Editing Tool

Hollywood Spec. Movie Script
Adobe Story Script Entity Tagging & Metadata

**Taxonomic vs. functional tagging**

Additional Labor  Mechanical Effects
Animal Handler  Music
Animals  Natural Phenomenon
Body of Water  Optical Effects
Camera  Painting
Cast Members  Production Notes
Celestial Body  Props
CGI  Public Transport
Character  Security
Construction  Seasons
Costume  Set
Crew  Set Dressing
Crowds  Sound
Electrics  Sound Effects
Extra  Special Equipment
Food & Drink  Special Effects
Greenery  Subtitles
Hair  Stunts
Holidays  Vehicles
Lights  Wardrobe
Livestock  Weapons
Location  Weather Phenomenon
Contextualizing and tuning both LO and UO is challenging
- Existing object ontologies (e.g., Wordnet) have sense bias
  - based on contributors
  - heavily biased towards term frequency found in news

General problems observed:
- Encountered errors in noun/verb disambiguation.
- Want to bias term sense towards movie production roles
- Without context, may select wrong sense:
  - e.g., “chess” as in a game vs. “chess” as a type of plant
  - pluralization frequently results in incorrect figurative sense
    - shoe vs. being in ones shoes,
    - arm vs. arms (in weapons sense)

Version 1 approaches:
- Augment manual ontology curation process with rules & tools
- Develop manual and automated heuristics
Lessons Learned About Building Ontologies
Heuristics We Developed Along the Way

- Automatically detect when LO entities are unmapped
- Bias entity term meanings towards tangible meanings
  - Prioritize sense selection for anatomy terms (eyes, legs, arms)
  - Select high specificity paths in LO (car isA vehicle vs. car isA container)
- Consolidate related temporal entities into one category
- Leverage script context in which entity occurred:
  - For ACTION entities, select less figurative meanings
  - For PARENTHETICALS entities, select facial gesture terminology
  - Use term occurrence in Dialog, Actions, Parentheticals, Scenes
Q/A Process & Methodology, Lessons Learned

- Built tag ground-truths for single scripts initially
- Continually evaluated/tuned classifier with ground truth
- Identified how LO remapping to UO generalized across scripts
- Used continual refinement of terms in UO
  - Analysis of production roles
  - Minimize UO categories
- Developed reporting functions for ground truth & QA
<table>
<thead>
<tr>
<th>Entity</th>
<th>UO-Category</th>
<th>LO-Category</th>
<th>Count</th>
<th>Scr</th>
<th>Inference Chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>242 candles</td>
<td>PROP_OBJECT</td>
<td>device#1</td>
<td>1 A</td>
<td></td>
<td>candle#1-&gt;lamp#1-&gt;source_of_illumination#1-&gt;device1</td>
</tr>
<tr>
<td>243 Cords</td>
<td>PROP_OBJECT</td>
<td>game#1</td>
<td>1 A</td>
<td></td>
<td>cord_game#1-&gt;game#1</td>
</tr>
<tr>
<td>244 Cauldron</td>
<td>PROP_OBJECT</td>
<td>implement#1</td>
<td>1 A</td>
<td></td>
<td>cauldron#1-&gt;pot#1-&gt;cooking_utensil#1-&gt;kitchen_utensil#1-&gt;utensil#1-&gt;implement1</td>
</tr>
<tr>
<td>245 Cheers</td>
<td>PROP_OBJECT</td>
<td>communication#2</td>
<td>1 A</td>
<td></td>
<td>cheer#1-&gt;approval#4-&gt;message#2-&gt;communication#2</td>
</tr>
<tr>
<td>246 brooms</td>
<td>PROP_OBJECT+MENTIONED_OBJECT</td>
<td>implement#1</td>
<td>2 A+D</td>
<td></td>
<td>broom#1-&gt;cleaning_implement#1-&gt;implement1</td>
</tr>
<tr>
<td>247 Camera</td>
<td>PROP_OBJECT+MENTIONED_OBJECT</td>
<td>photographic_equipment#1</td>
<td>7 D+A</td>
<td></td>
<td>camera#1-&gt;photographic_equipment1</td>
</tr>
<tr>
<td>248 camera</td>
<td>PROP_OBJECT+MENTIONED_OBJECT</td>
<td>photographic_equipment#1</td>
<td>5 A+D</td>
<td></td>
<td>camera#1-&gt;photographic_equipment1</td>
</tr>
<tr>
<td>249 approach</td>
<td>PROP_OBJECT+SET_DRESSING</td>
<td>creation#1</td>
<td>1 A</td>
<td></td>
<td>approach#1-&gt;conceptualization#1-&gt;creating_by_mentalActs#1-&gt;creation1</td>
</tr>
<tr>
<td>250 Bathroom</td>
<td>SCENE_LOCATION</td>
<td>area#5</td>
<td>7 S</td>
<td></td>
<td>bathroom#1-&gt;room#1-&gt;area#5</td>
</tr>
<tr>
<td>251 Bedroom</td>
<td>SCENE_LOCATION</td>
<td>area#5</td>
<td>8 S</td>
<td></td>
<td>bedroom#1-&gt;room#1-&gt;area#5</td>
</tr>
<tr>
<td>252 Black Park</td>
<td>SCENE_LOCATION</td>
<td>geographical_area#1</td>
<td>1 S</td>
<td></td>
<td>Black</td>
</tr>
<tr>
<td>253 Castle</td>
<td>SCENE_LOCATION</td>
<td>structure#1</td>
<td>4 S</td>
<td></td>
<td>palace#1-&gt;mansion#2-&gt;house#1-&gt;dwelling#1-&gt;housing#1-&gt;structure#1</td>
</tr>
<tr>
<td>254 alcove</td>
<td>SET</td>
<td>area#5</td>
<td>1 A</td>
<td></td>
<td>alcove#1-&gt;recess#4-&gt;enclosure#1-&gt;area#5</td>
</tr>
<tr>
<td>255 area</td>
<td>SET</td>
<td>area#1</td>
<td>1 A</td>
<td></td>
<td>area#1</td>
</tr>
<tr>
<td>256 chimney</td>
<td>SET</td>
<td>way#5</td>
<td>1 A</td>
<td></td>
<td>chimney#1-&gt;flue#3-&gt;conduit#1-&gt;passage#3-&gt;way#6</td>
</tr>
<tr>
<td>257 archway</td>
<td>SET_DRESSING</td>
<td>entrance#1</td>
<td>1 A</td>
<td></td>
<td>arch#1-&gt;entrance#1</td>
</tr>
<tr>
<td>258 banisters</td>
<td>SET_DRESSING</td>
<td>barrier#1</td>
<td>1 A</td>
<td></td>
<td>bannister#1-&gt;barrier#1</td>
</tr>
<tr>
<td>259 bed</td>
<td>SET_DRESSING</td>
<td>furniture#1</td>
<td>9 A+D</td>
<td></td>
<td>bed#1-&gt;bedroom_furniture#1-&gt;furniture#1</td>
</tr>
<tr>
<td>260 Burrow</td>
<td>SET+SCENE_LOCATION</td>
<td>geological_form#1</td>
<td>4 S+A</td>
<td></td>
<td>burrow#1-&gt;hole#5-&gt;natural_depression#1-&gt;geological_form#1</td>
</tr>
<tr>
<td>261 Banging</td>
<td>SOUND</td>
<td>noise#1</td>
<td>1 A</td>
<td></td>
<td>banging#1-&gt;noise#1</td>
</tr>
<tr>
<td>262 Car</td>
<td>VEHICLES</td>
<td>vehicle#1</td>
<td>6 S+D+A</td>
<td></td>
<td>car#1-&gt;motor_vehicle#1-&gt;self-propelled_vehicle#1-&gt;wheeled_vehicle#1-&gt;vehicle#1</td>
</tr>
<tr>
<td>263 car</td>
<td>VEHICLES</td>
<td>vehicle#1</td>
<td>23 D+A</td>
<td></td>
<td>car#1-&gt;motor_vehicle#1-&gt;vehicle#1-&gt;self-propelled_vehicle#1-&gt;wheeled_vehicle#1-&gt;vehicle#1</td>
</tr>
<tr>
<td>264 cars</td>
<td>VEHICLES</td>
<td>vehicle#1</td>
<td>1 A</td>
<td></td>
<td>car#1-&gt;motor_vehicle#1-&gt;self-propelled_vehicle#1-&gt;wheeled_vehicle#1-&gt;vehicle#1</td>
</tr>
<tr>
<td>265 bedclothes</td>
<td>WARDROBE</td>
<td>cloth_covering#1</td>
<td>1 A</td>
<td></td>
<td>bedclothes#1-&gt;cloth_covering#1</td>
</tr>
<tr>
<td>266 boot</td>
<td>WARDROBE</td>
<td>footwear#2</td>
<td>4 A+D</td>
<td></td>
<td>boot#1-&gt;footwear#2</td>
</tr>
<tr>
<td>267 class</td>
<td>PROP_OBJECT+MENTIONED_OBJECT</td>
<td>collection#1</td>
<td>4 A+D</td>
<td></td>
<td>class#1-&gt;collection#1</td>
</tr>
</tbody>
</table>
### Adobe Story Metadata Reporting Function

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>INT. SINCLAIR KITCHEN</td>
<td>INT. SINCLAIR KITCHEN</td>
<td>DAY</td>
<td>87</td>
<td>TIGHT ON</td>
<td>WOMAN</td>
<td>WOMAN: Here you</td>
<td>1</td>
<td>87</td>
<td>0</td>
<td>Cast Members: boy, CHILD,</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>EXT. OPEN PASTURE - NE EXT.</td>
<td>OPEN PASTURE</td>
<td>NIGHT</td>
<td>84</td>
<td>The pasture is</td>
<td>JENNIFER</td>
<td>JENNIFER: Yeah, I</td>
<td>2</td>
<td>84</td>
<td>87</td>
<td>Cast Members: bastard,</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>EXT. BURGER JOINT - LOL EXT.</td>
<td>BURGER JOINT - LOUISIANA</td>
<td>NIGHT</td>
<td>137</td>
<td>Sitting at a</td>
<td>PAIGE</td>
<td>PAIGE: There's a</td>
<td>4</td>
<td>137</td>
<td>173</td>
<td>Cast Members: brother,</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>INT. PARKING LOT - BURG EXT.</td>
<td>PARKING LOT - BURGER JOINT</td>
<td>SAME TIME</td>
<td>51</td>
<td>A brand new,</td>
<td>PAIGE</td>
<td>PAIGE:Blake.</td>
<td>5</td>
<td>51</td>
<td>330</td>
<td>Cast Members: drivers,</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>INT. WADDE'S DOODLE CHAIN</td>
<td>WADDE'S DOODLE CHAIN (MOVING)</td>
<td>LATER THAT</td>
<td>130</td>
<td>Wade drives,</td>
<td>RADIO (V.O.)</td>
<td>RADIO (V.O.)</td>
<td>6</td>
<td>130</td>
<td>361</td>
<td>Animals: Charger,</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>EXT. TWO-LANE - NIGHT EXT.</td>
<td>TWO-LANE ROAD</td>
<td>NIGHT</td>
<td>40</td>
<td>Wade follows</td>
<td>WADE</td>
<td>WADE: Huh, Wax</td>
<td>7</td>
<td>40</td>
<td>495</td>
<td>Character: Carly</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>EXT. DIRT ROAD - NIGHT EXT.</td>
<td>DIRT ROAD - NIGHT</td>
<td>SAME</td>
<td>8</td>
<td>As Blake's</td>
<td>8</td>
<td>8</td>
<td>533</td>
<td>Construction: road</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>EXT. CLEARING - BACK OF EXT.</td>
<td>CLEARING - BACK OF CARS</td>
<td>NIGHT</td>
<td>218</td>
<td>The Escalade</td>
<td>CARLY</td>
<td>CARLY: Dalton what</td>
<td>9</td>
<td>218</td>
<td>520</td>
<td>Animals: Charger</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>EXT. CLEARING - CAMPSE EXT.</td>
<td>CLEARING - CAMPSE - LAKE SIDE</td>
<td>NIGHT</td>
<td>38</td>
<td>Music BLASTS.</td>
<td>CARLY</td>
<td>CARLY: Dalton what</td>
<td>10</td>
<td>38</td>
<td>757</td>
<td>Character: Carly</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>BLAKE'S TENT - SAM INT.</td>
<td>BLAKE'S TENT</td>
<td>SAME</td>
<td>7</td>
<td>Carly and Paige</td>
<td>11</td>
<td>7</td>
<td>795</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>EXT. CLEARING - DATES EXT.</td>
<td>CLEARING - CAMPSE</td>
<td>A LITTLE LATE</td>
<td>120</td>
<td>Carly comes</td>
<td>CARLY</td>
<td>CARLY: C'mon,</td>
<td>12</td>
<td>120</td>
<td>802</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>EXT. CAMPSE - LATE INT.</td>
<td>CAMPSE</td>
<td>SAME</td>
<td>24</td>
<td>A full moon</td>
<td>CAMPSE</td>
<td>CAMPSE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>INT. TENT - NIGHT - SAM INT.</td>
<td>TENT - NIGHT</td>
<td>SAME</td>
<td>48</td>
<td>Carly snaps</td>
<td>CARLY</td>
<td>CARLY: Wade.</td>
<td>14</td>
<td>48</td>
<td>946</td>
<td>Cast Members: Peeks</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>EXT. CAMPSE - NEXT OF INT.</td>
<td>CAMPSE</td>
<td>NEXT DAY</td>
<td>12</td>
<td>Blake peeks his</td>
<td>BLAKE</td>
<td>BLAKE:</td>
<td>15</td>
<td>12</td>
<td>994</td>
<td>Props: wristwatch</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>EXT. CHARGET/ESCAlade - NIGHT EXT.</td>
<td>CHARGET/ESCAlade - DAY</td>
<td>SOON AFTER</td>
<td>15</td>
<td>The camp's</td>
<td>DALTON</td>
<td>DALTON: Dude, did</td>
<td>16</td>
<td>15</td>
<td>1006</td>
<td>Cast Members: boys, driver,</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>EXT. FRONT OF CHARGER - NIGHT EXT.</td>
<td>FRONT OF CHARGER - DAY</td>
<td>CONTINUOUS</td>
<td>8</td>
<td>They all gather</td>
<td>WADE</td>
<td>WADE: Are you sure</td>
<td>17</td>
<td>8</td>
<td>1021</td>
<td>Animals: snake</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>INT. TIES - DAY - SAME INT.</td>
<td>TREES - DAY</td>
<td>SAME</td>
<td>48</td>
<td>The girls have</td>
<td>PAIGE</td>
<td>PAIGE: You and</td>
<td>18</td>
<td>48</td>
<td>1029</td>
<td>Cast Members: girls</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>EXT. CLEARING - DAY - CC EXT.</td>
<td>CLEARING - DAY</td>
<td>4 Carly slides</td>
<td>4</td>
<td>Carly slides</td>
<td>4</td>
<td>4</td>
<td>1077</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>INSIDE THE PIT</td>
<td>INSIDE THE PIT</td>
<td>61</td>
<td>Carly's eyes</td>
<td>CARLY</td>
<td>CARLY: Paigel Help</td>
<td>20</td>
<td>61</td>
<td>1081</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>A BEAT TO CRAP PICKUP</td>
<td>A BEAT TO CRAP PICKUP TRUCK</td>
<td>265</td>
<td>making it's way</td>
<td>BLAKE</td>
<td>BLAKE: That the</td>
<td>21</td>
<td>265</td>
<td>1142</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>EXT. OTHER SIDE OF THE EXT.</td>
<td>OTHER SIDE OF THE PIT - LESTER'S TRUCK</td>
<td>DAY</td>
<td>31</td>
<td>Lester opens</td>
<td>WADE</td>
<td>WADE: It's not so</td>
<td>22</td>
<td>31</td>
<td>1347</td>
<td>Character: Carly, Lester</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>INT. LESTER'S TRUCK - LESTER'S TRUCK</td>
<td>DAY</td>
<td>131</td>
<td>Lester, Carly</td>
<td>CARLY</td>
<td>CARLY: Can you roll</td>
<td>23</td>
<td>131</td>
<td>1378</td>
<td>Cast Members: cranked, guy</td>
<td>26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>EXT. WASHED OUT ROAD EXT.</td>
<td>WASHED OUT ROAD</td>
<td>DAY</td>
<td>60</td>
<td>Lester</td>
<td>WADE</td>
<td>WADE: What's</td>
<td>24</td>
<td>60</td>
<td>1509</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>EXT. WASHED OUT ROAD EXT.</td>
<td>WASHED OUT ROAD</td>
<td>CONTINUOUS</td>
<td>24</td>
<td>Lester gets out.</td>
<td>WADE</td>
<td>LESTER: Get out</td>
<td>25</td>
<td>24</td>
<td>1569</td>
<td>Character: Carly, Lester</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>EXT. WASHED OUT ROAD EXT.</td>
<td>WASHED OUT ROAD</td>
<td>DAY</td>
<td>17</td>
<td>Wade takes</td>
<td>CARLY: No still</td>
<td>26</td>
<td>17</td>
<td>1595</td>
<td>Character: Carly, Lester</td>
<td>29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>OTHER SIDE OF WASH OF OTHER SIDE OF WASH OUT - DAY</td>
<td>CONTINUOUS</td>
<td>17</td>
<td>They reach</td>
<td>WADE: Damn. Now</td>
<td>27</td>
<td>17</td>
<td>1610</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>EXT. TOWN OF AMBROSE - TOWN OF AMBROSE EXT.</td>
<td>TOWN OF AMBROSE - DAY</td>
<td>ESTABLISHED</td>
<td>55</td>
<td>Unfolding</td>
<td>WADE</td>
<td>WADE: Miss</td>
<td>28</td>
<td>55</td>
<td>1627</td>
<td>Animals: dog, puppies</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>EXT. GAS STATION - DAY EXT.</td>
<td>GAS STATION - DAY</td>
<td>RIGHT AFTER</td>
<td>22</td>
<td>Wade and</td>
<td>WADE</td>
<td>WADE: $1,197 Are</td>
<td>29</td>
<td>22</td>
<td>1682</td>
<td>Character: Carly</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>INT. ESCALADE - SAME INT.</td>
<td>ESCALADE</td>
<td>SAME TIME</td>
<td>36</td>
<td>The Escalade</td>
<td>NICK</td>
<td>NICK: Dude, it's</td>
<td>30</td>
<td>36</td>
<td>1704</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>EXT. MAIN STREET - DAY EXT.</td>
<td>MAIN STREET - DAY</td>
<td>RIGHT AFTER</td>
<td>95</td>
<td>Carly and</td>
<td>CARLY</td>
<td>CARLY: Hello?</td>
<td>31</td>
<td>95</td>
<td>1744</td>
<td>Animals: dog, phantasm</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>EXT. CAMPSE - COMBINED WITH 27</td>
<td></td>
<td>2</td>
<td>33</td>
<td>1830</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>EXT. FRONT OF CHURCH - EXT.</td>
<td>FRONT OF CHURCH - DAY</td>
<td>RIGHT AFTER</td>
<td>10</td>
<td>Carly and</td>
<td>34</td>
<td>10</td>
<td>1832</td>
<td>Character: Carly</td>
<td>34</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>INT. CHURCH - DAY</td>
<td>CHURCH - DAY</td>
<td>CONTINUOUS</td>
<td>24</td>
<td>And Carly</td>
<td>CARLY: Um, I don't</td>
<td>34</td>
<td>24</td>
<td>1842</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>INT. CAMPSE - DAY</td>
<td>CAMPSE - DAY</td>
<td>CONTINUOUS</td>
<td>134</td>
<td>As the two of</td>
<td>CARLY</td>
<td>CARLY: So should</td>
<td>35</td>
<td>134</td>
<td>1866</td>
<td>Cast Members: guard, guy</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>INT. SINGLE FLAME CU ON THE SINGLE FLAME OF A CANDLE</td>
<td>INT. SINGLE FLAME CU ON THE SINGLE FLAME OF A CANDLE</td>
<td>DAY</td>
<td>14</td>
<td>It moves and</td>
<td>36</td>
<td>14</td>
<td>2000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>INT. SOME KIND OF BASEMENT</td>
<td>SOME KIND OF BASEMENT</td>
<td>DAY</td>
<td>35</td>
<td>CU on strong</td>
<td>CARLY O.S.</td>
<td>CARLY O.S.</td>
<td>38</td>
<td>35</td>
<td>2014</td>
<td>Cast Members: artist, male,</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>EXT. HOUSE OF WAX - FRONT DOOR</td>
<td>HOUSE OF WAX - PORCH</td>
<td>DAY</td>
<td>22</td>
<td>CU on FINGERS</td>
<td>WADE</td>
<td>WADE: It's a House</td>
<td>39</td>
<td>22</td>
<td>2095</td>
<td>Character: Carly</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>EXT. HOUSE OF WAX - PORCH</td>
<td>HOUSE OF WAX - Foyer</td>
<td>DAY</td>
<td>21</td>
<td>They stop</td>
<td>WADE</td>
<td>WADE: Looks like a</td>
<td>40</td>
<td>21</td>
<td>2095</td>
<td>Cast Members: barnstormers,</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>INT. PIANO ROOM - CON</td>
<td>PIANO ROOM - CON</td>
<td>CONTINUOUS</td>
<td>52</td>
<td>A PLAYER</td>
<td>CARLY</td>
<td>CARLY: Vincent</td>
<td>41</td>
<td>52</td>
<td>2177</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>INT. DINING AREA - DAY</td>
<td>DINING AREA - DAY</td>
<td>CONTINUOUS</td>
<td>22</td>
<td>Wade bount</td>
<td>WADE</td>
<td>WADE: Now this is</td>
<td>42</td>
<td>22</td>
<td>2229</td>
<td>Animals: pig</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>INT. PIANO ROOM - CON</td>
<td>PIANO ROOM - CON</td>
<td>CONTINUOUS</td>
<td>41</td>
<td>Carly glances at CARLY</td>
<td>CARLY: When's the</td>
<td>43</td>
<td>41</td>
<td>2255</td>
<td>Character: Carly</td>
<td>43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>EXT. HOUSE OF WAX - FRONT DOOR</td>
<td>HOUSE OF WAX - FRONT DOOR</td>
<td>DAY</td>
<td>21</td>
<td>Single</td>
<td>WADE</td>
<td>WADE: Hang here a</td>
<td>44</td>
<td>21</td>
<td>2258</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>EXT. HOUSE OF WAX - SIT EXT.</td>
<td>HOUSE OF WAX - SIDE YARD - DAY</td>
<td>SAME</td>
<td>4</td>
<td>Wade continues his search.</td>
<td>45</td>
<td>4</td>
<td>2331</td>
<td>Construction: DOORS</td>
<td>43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>INT. HOUSE OF WAX - INT</td>
<td>INT. HOUSE OF WAX - INT</td>
<td>SAME</td>
<td>7</td>
<td>Carly passes</td>
<td>46</td>
<td>7</td>
<td>2317</td>
<td>Character: Carly</td>
<td>46</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Future Semantic Directions for Adobe Story

1. Add feedback loop for editors to annotate & score selected auto-tags

2. Use supervised Machine Learning to improve auto-tagging by incorporating expertise of reviewers

3. Leverage Mechanical Turk approaches or crowd-sourcing
   a. To increase quality, re-formulate tagging questions as crowd-sourcing task
   b. Gather and leverage occurrence statistics directly
   c. Use co-occurring words to contextualize re-mappings
   d. Employ Bayesian Inferencing techniques
Concluding Comments

- Special thanks to:
  
  Adobe Story Program & Product Management.
  Engineering, Localization, and Q/E Teams

- Questions, comments about this presentation?

  Walter Chang – wachang@adobe.com
  Marci Meingast – marci@adobe.com

- Learn more about Adobe Story or try it at:


  THANK YOU!