Apache UIMA y el Sistema Watson Jeopardy

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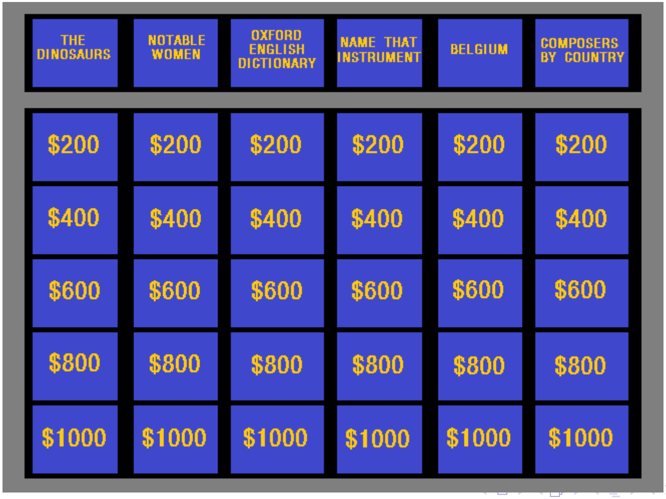
Outline

Outline

Problem



THE DINOSAURS	NOTABLE WOMEN	OXFORD ENGLISH DICTIONARY	NAME THAT INSTRUMENT	BELGIUM	COMPOSERS BY COUNTRY
$200	$200	$200	$200	$200	$200
$400	$400	$400	$400	$400	$400
$600	$600	$600	$600	$600	$600
$800	$800	$800	$800	$800	$800
$1000	$1000	$1000	$1000	$1000	$1000

Example Questions

Categoría: "J.P."
He played Duke Washburn, Curly's twin brother, in "City Slickers II".

- Respuesta: Jack Palance

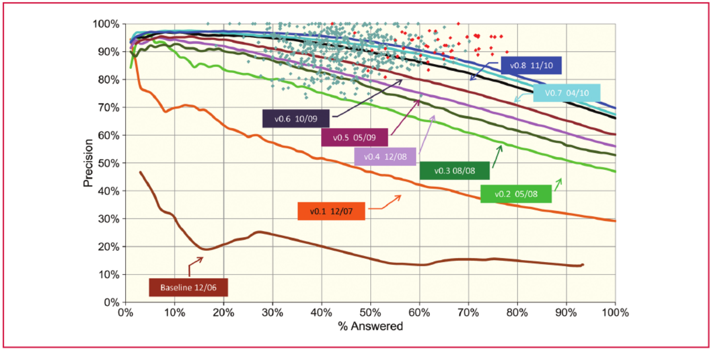
About the Speaker

- UNC-FAMAF
  - Trabajo Final: “Desarrollo de un Parser Funcional para el Lenguaje Castellano”, presentado Ago. 1998.
- Columbia University
  - Natural Language Generation
  - PhD Thesis: “Indirect Supervised Learning of Strategic Generation Logic”, defendida Ene. 2005.
- IBM Research Watson
  - Question Answering
  - Deep QA - Watson
- Investigador independiente viviendo en Montreal (Canadá)
  - Colaboración con Université de Montreal
  - Free Software projects and consulting for small companies

The Challenges of a Research Team

- Velocidad de desarrollo inusitadamente alta
  - Un *turn-around* experimental no es una propiedad *“nice to have”*, es clave
- Dead code
- Sin documentación
- Reproducibilidad de los resultados

Architecture



Incremental progress from June 2007 to November 2010, from Ferrucci (2012)

The Challenges of a Grand Challenge

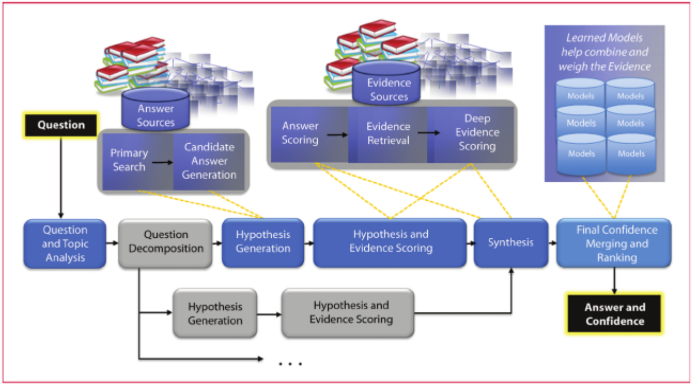
- Very expensive.
- Constantly on the verge of being canceled.
- Plenty of issues beyond the control of the research team.

Outline

Approach

- Mantener todas las interpretaciones abiertas hasta el final
  - No decidirse a algo antes de tiempo (*overcommit*)
- Proponer respuestas candidatas haciendo búsquedas
- Conseguir evidencia de soporte haciendo una búsqueda para cada respuesta candidata (!)
- Analizar todo esta cornucopia de información en paralelo
- *Scoring* y *ranking* centralizado usando Aprendizaje Automático

Architecture



DeepQA Architecture, from Ferrucci (2012)

Components Descriptions

Question Analysis. Extract keywords, assign to known classes, expand entities.

Primary Search. Obtain a set of documents relevant to the question.

Candidate Answer Generation. Extract from the documents candidate answers.

Evidence Retrieval and Scoring. Fetch passages (sentences) containing the candidate answers and relevant keywords, then score the candidates in context.

Final Confidence Merging. Apply a trained model based on the evidence.

Outline

Frameworks

- Frameworks enable:
  - Sharing and Collaboration
  - Growth
  - Deployment and Large scale implementations
  - Adoption
- Frameworks need:
  - Maintenance (no software is ever “completed”)
  - Documentation (to further collaboration / adoption)
  - Neutrality (w.r.t. applications being implemented)
  - Ownership (on behalf of their developers / maintainers)
  - Publicity (for widespread adoption)

Enabling Sharing and Collaboration

- Sharing within an organization
  - Code is the documentation
  - Agile sharing
  - Convention-over-configuration
- Sharing with the world
  - Enabling the greater good, without paying a high price (support time, spoiling potential ventures)
- Sharing with new / potential partners
  - Bringing new people up to speed
  - Attracting talent

Enabling Growth

- New phenomena
  - From syntactic parsing to semantic parsing
  - From parsing sentences to parsing USB traffic data
- New artifacts
  - From text to speech
- New architectures
  - From Understanding to Generation

Enable Deployment and Large scale implementations

- Multiple architectures
  - Windows, Linux
- On-line vs. off-line
  - Batch corpus processing vs. user-oriented Web services
- New programming languages (and old, efficient ones)
- New human languages

What is UIMA

- UIMA is a framework, a means to integrate text or other unstructured information analytics.
- Reference implementations available for Java, C++ and others.
- An Open Source project under the umbrella of the Apache Foundation.

Analytics Frameworks

- Find all telephone numbers in running text
  - `(((\([0-9]{3}\))|[0-9]{3})-?[0-9]{3}-?[0-9]{4}`
- Nice but...
  - How are you going to feed this result for further processing?
  - What about finding non-standard proper names in text?
  - Acquiring technology from external vendors, free software projects, etc?

In-line Annotations

- Modify text to include annotations
  - This/DET happy/ADJ puppy/N
- It gets very messy very quickly
  - (S (NP (This/DET happy/ADJ puppy/N) (VP eats/V (NP (the/DET bone/N)))
- Annotations can easily cross boundaries of other annotations
  - He said **<confidential>**the project can't go on. The funding is lacking.**</confidential>**

Standoff Annotations

- Standoff annotations
  - Do not modify the text
  - Keep the annotations as offsets within the original text
- Most analytics frameworks support standoff annotations.
- UIMA is built with standoff annotations at its core.
- Example:

```
He said the project can't go on.  The funding is lacking.
---------------------------------------------------------
0123456789012345678901235678901234567890123456789012345667
```

  - Sentence Annotation: 0-32, 35-57.
  - Confidential Annotation: 8-57.

Type Systems

- Key to integrating analytic packages developed by independent vendors.
- Clear metadata about
  - Expected Inputs
    - Tokens, sentences, proper names, etc
  - Produced Outputs
    - Parse trees, opinions, etc
- The framework creates an unified typesystem for a given set of annotators being run.

UIMA Advantages

- CAS
  - Memory Efficiency
  - Indices
- Types
- Interoperability
- Lean protocol serialization
  - UIMA AS sends and retrieves from network nodes only the required information
  - (default XMI serialization is anything but lean)

Outline

UIMA Concepts

- Common Annotation Structure or CAS
  - Subject of Analysis (SofA or View)
  - JCas
- Feature Structures
  - Annotations
- Indices and Iterators
- Analysis Engines (AEs)
  - AEs descriptors

Room annotator

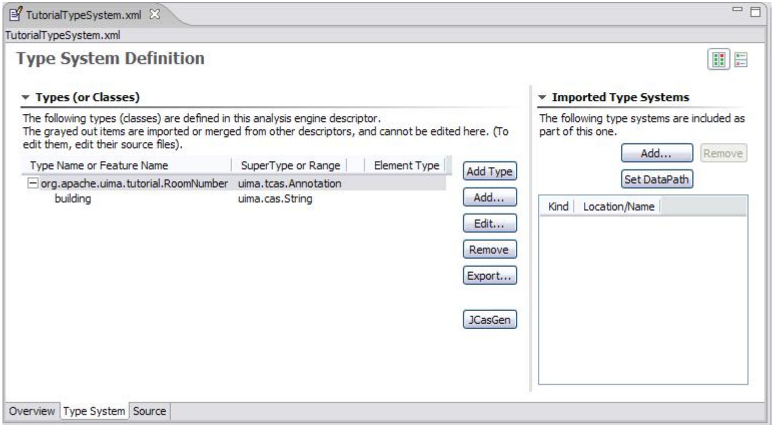
- From the UIMA tutorial, write an Analysis Engine that identifies room numbers in text.

  Yorktown patterns: 20-001, 31-206, 04-123 (Regular Expression Pattern: [0-9][0-9]-[0-2][0-9][0-9])

  Hawthorne patterns: GN-K35, 1S-L07, 4N-B21 (Regular Expression Pattern: [G1-4][NS]-[A-Z][0-9])

- Steps:
  1. Define the CAS types that the annotator will use.
  2. Generate the Java classes for these types.
  3. Write the actual annotator Java code.
  4. Create the Analysis Engine descriptor.
  5. Test the annotator.

Editing a Type System


TutorialTypeSystem.xml

Type System Definition

Types (or Classes)

The following types (classes) are defined in this analysis engine descriptor.
The grayed out items are imported or merged from other descriptors, and cannot be edited here. (To edit them, edit their source files).

Type Name or Feature Name	SuperType or Range	Element Type
org.apache.uima.tutorial.RoomNumber	uima.tcas.Annotation	
building	uima.cas.String	

Imported Type Systems

The following type systems are included as part of this one.

Kind	Location/Name

The XML descriptor

```
<?xml version="1.0" encoding="UTF-8" ?>
  <typeSystemDescription xmlns="http://uima.apache.org/resourceSpecifier">
    <name>TutorialTypeSystem</name>
    <description>Type System Definition for the tutorial examples -
        as of Exercise 1</description>
    <vendor>Apache Software Foundation</vendor>
    <version>1.0</version>
    <types>
      <typeDescription>
        <name>org.apache.uima.tutorial.RoomNumber</name>
        <description></description>
        <supertypeName>uima.tcas.Annotation</supertypeName>
        <features>
          <featureDescription>
            <name>building</name>
            <description>Building containing this room</description>
            <rangeTypeName>uima.cas.String</rangeTypeName>
          </featureDescription>
        </features>
      </typeDescription>
    </types>
  </typeSystemDescription>
```

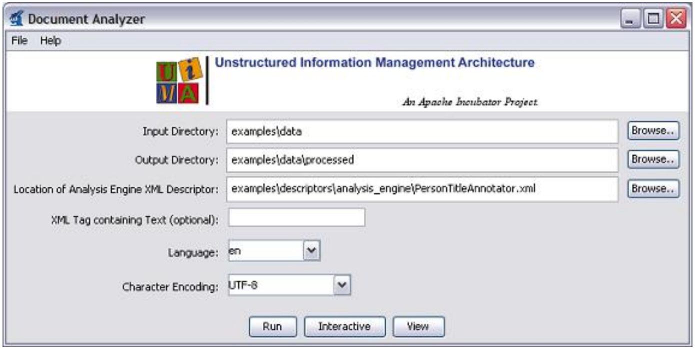
The AE code

```java
package org.apache.uima.tutorial.ex1;

import java.util.regex.Matcher;
import java.util.regex.Pattern;

import org.apache.uima.analysis_component.JCasAnnotator_ImplBase;
import org.apache.uima.jcas.JCas;
import org.apache.uima.tutorial.RoomNumber;

/**
 * Example annotator that detects room numbers using
 * Java 1.4 regular expressions.
 */
public class RoomNumberAnnotator extends JCasAnnotator_ImplBase {
  private Pattern mYorktownPattern =
        Pattern.compile("\\b[0-4]\\d-[0-2]\\d\\d\\b");

  private Pattern mHawthornePattern =
        Pattern.compile("\\b[G1-4][NS]-[A-Z]\\d\\d\\b");

  public void process(JCas aJCas) {
    // next slide
  }
}
```

The AE code (cont.)

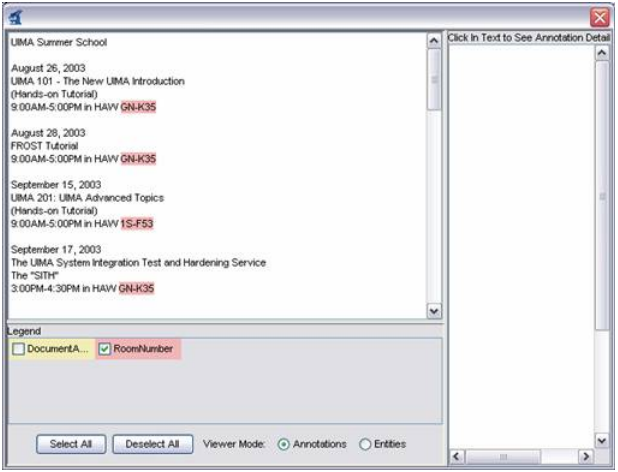
```java
public void process(JCas aJCas) {
  // get document text
  String docText = aJCas.getDocumentText();
  // search for Yorktown room numbers
  Matcher matcher = mYorktownPattern.matcher(docText);
  int pos = 0;
  while (matcher.find(pos)) {
    // found one — create annotation
    RoomNumber annotation = new RoomNumber(aJCas);
    annotation.setBegin(matcher.start());
    annotation.setEnd(matcher.end());
    annotation.setBuilding("Yorktown");
    annotation.addToIndexes();
    pos = matcher.end();
  }
  // search for Hawthorne room numbers
  // ..
}
```

UIMA Document Analyzer


Document Analyzer
File Help
Unstructured Information Management Architecture
An Apache Incubator Project
Browse..
Browse..
Browse..
Run
Interactive
View

Input Directory: examples\data
Output Directory: examples\data\processed
Location of Analysis Engine XML Descriptor: examples\descriptors\analysis_engine\PersonTitleAnnotator.xml
XML Tag containing Text (optional):
Language: en
Character Encoding: UTF-8

UIMA Document Analyzer (cont)


UIMA Summer School

August 26, 2003
UIMA 101 - The New UIMA Introduction
(Hands-on Tutorial)
9:00AM-5:00PM in HAW GN-K35

August 28, 2003
FROST Tutorial
9:00AM-5:00PM in HAW GN-K35

September 15, 2003
UIMA 201: UIMA Advanced Topics
(Hands-on Tutorial)
9:00AM-5:00PM in HAW 1S-F53

September 17, 2003
The UIMA System Integration Test and Hardening Service
The "SITH"
3:00PM-4:30PM in HAW GN-K35

Legend
☐ DocumentA... ✓ RoomNumber

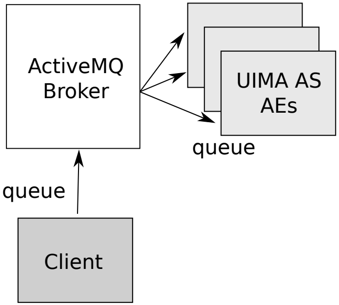
Viewer Mode: [✓ Annotations] Entities

Custom Flow Controllers

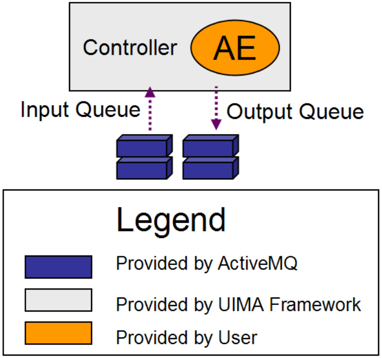
- UIMA permite especificar cual AE deberá procesar la CAS en le paso siguiente, basado en las anotaciones que ya están en la CAS.
- `examples/descriptors/flow_controller/WhiteboardFlowController.xml`
  - FlowController que implementa un modelo de flujo simple de tipo “whiteboard” (pizarrón). Cada vez que recibe una CAS. se fija en el *pool* de AEs que todavía no han ejecutado sobre esa CAS y elije uno cuyos requerimientos de entrada ya hayan sido satisfechos.

Outline

UIMA AS: ActiveMQ



UIMA AS: Wrapping Primitive AEs



UIMA AS: Advantages

- Muy flexible en térmios de dividir la carga de trabajo entres los nodos
  - Tienes control total sobre como dividir las colas en sub-colas, etc.
- Muy eficiente en términos de *overhead* en la red
  - Una CAS que va a ser dividida y procesada varias veces (en partes distintas) es enviada sólo una vez.
  - Sólo las anotaciones **requeridas** son enviadas y las anotaciones **nuevas** son devueltas.
    - Archivos de metadata (descriptores) son clave para que ésto funcione

UIMA AS: More information

- `http://uima.apache.org/doc-uimaas-what.html`
- `http://svn.apache.org/viewvc/uima/uima-as/trunk/README?view=markup`
- `http://uima.apache.org/d/uima-as-2.4.2/uima_async_scaleout.html`

Many frameworks

- Besides UIMA
  - `http://uima.apache.org`
- LingPipe
  - `http://alias-i.com/lingpipe/`
- Gate
  - `http://gate.ac.uk/`
- NLTK
  - `http://www.nltk.org/`

UIMA Advantages

- Apache Licensed
- Enterprise-ready code quality
- Demonstrated scalability
- Developed by experts in building frameworks
  - Not domain (e.g., NLP) experts
- Interoperable (C++, Java, others)

How Hard is to Learn UIMA?

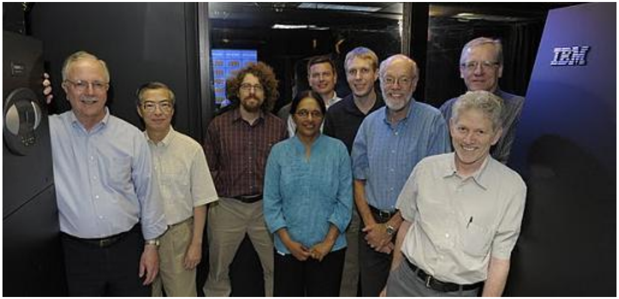
- Es bien difíl.
- La documentación es muy buena pero muy extensa.
  - Si pueden tomarse el tiempo de leerla de punta a punta, es de fácil lectura.
- Usen las herramientas de Eclipse cuando sea posible.
- Aprendan primero uimaFIT, después JCas, y CAS sólo si hace falta.
- Enfoquense en los *“goodies”*:
  - Apache UIMA Ruta – anotación basada en reglas
  - OpenNLP – modelos ya entrenados para POS, NER, etc., y bien fácil de entrenar tus propios modelos
  - ClearTk – un *wrapper* para librerias de aprendizaje automático

Outline

My Contributions in the Watson System

- Sources Team
- Internal Tooling
- Machine learning in watson

Systems Team

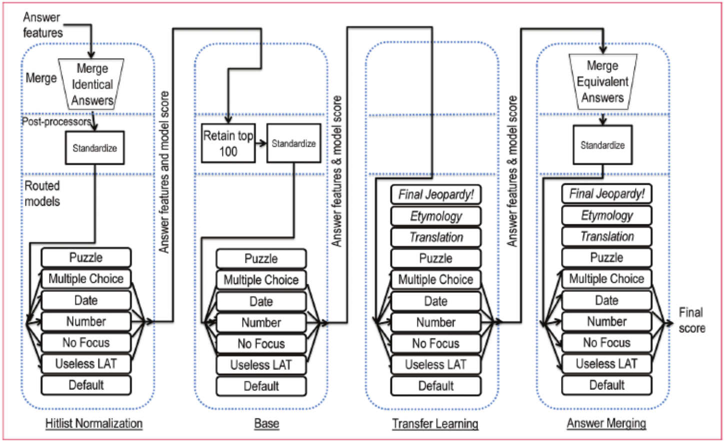


Systems Team, from `https://www.research.ibm.com/deepqa/`.

Machine Learning in Watson

- Multiple phases of Logistic Regression
- Feature Engineering
- DSL for Feature Engineering

First Four Phases of Merging and Ranking



from Gondek, Lally, Kalyanpur, Murdock, Duboue, Zhang, Pan, Qiu, Welty (2012)

Outline

After Watson

- Consulting
- Academic Work
  - Teaching
  - Hunter Gatherer
  - Thoughtland
- Free Software

Consulting

- MatchFWD: LinkedIn data
- UrbanOrca: Facebook data
- KeaText: legal data
- Radialpoint: tech support data
- Contact me at `http://duboue.net`

Academic Work

- Dicté la materia “Generación de Lenguaje Natural” para el programa de doctorado en FAMAF-UNC.
- Algunas publicaciones recientes:
  - **Pablo Duboue**, Jing He and Jian-Yun Nie. *“Hunter Gatherer: UdeM at 1Click-2”*. NTCIR (2013).
  - Pablo Duboue. *“On the Feasibility of Automatically Describing n-dimensional Objects”*. EWNLG (2013).
  - Pablo Duboue. *Thoughtland: Natural Language Descriptions for Machine Learning n-dimensional Error Functions (demo)”*. Proc. of EWNLG (2013).
  - Jing He, **Pablo Duboue**, and Jian-Yun Nie. *“Bridging the Gap between Intrinsic and Perceived Relevance in Snippet Generation””*. COLING (2012).
  - Fabian Pacheco, **Pablo Duboue**, and Martin Dominguez. *“On The Feasibility of Open Domain Referring Expression Generation Using Large Scale Folksonomies (short paper)”*. NAACL (2012).
  - Pablo Duboue. *“Extractive email thread summarization: Can we do better than He Said She Said?”*. INLG (2012).
  - David Nicolas Racca, Luciana Benotti, and **Pablo Duboue**. *“The GIVE-2.5 C Generation System”* EWNLG (2011).

Hunter Gatherer

- What? 1-Click Search
  - Input: Query and 200 ranked Web pages
  - Output: a 1,000 characters summary
    - Summary should contain the information the pages relevant to the query.
- A research challenge part of NTICR
- Queries belong to 8 types (celebrities, how to, location, etc)
  - But the type is not explicit

Hunter Gatherer Approach

- Apply the DeepQA architecture to 1-Click task
  - Do not explicitly type the query
- Hunt nuggets, gather evidence
  1. Hunt text nuggets on relevant passages
  2. Gather evidence passages that contain nuggets and query terms
  3. Score nuggets based on evidence
  4. Final output are sentences containing highly scored nuggets

`https://github.com/DrDub/hunter-gatherer`

Thoughtland

- Generation of textual descriptions for *n*-dimensional data.
  - Early stage research
  - Focus on describing the error surface for Machine Learning models
- Presented at the European Workshop in Natural Language Generation in Sofia, Bulgaria (2013)
- Written in Scala, using Mahout on top of Hadoop for clustering and Weka for machine learning.
- Demo: `http://thoughtland.duboue.net`
- Code: `https://github.com/DrDub/Thoughtland`

Thoughtland: Input

- A small data set from the UCI ML repo, the Auto-Mpg Data:

`http://archive.ics.uci.edu/ml/machine-learning-databases/auto-mpg/`

```
@relation auto_mpg
@attribute mpg numeric
@attribute cylinders numeric
@attribute displacement numeric
@attribute horsepower numeric
@attribute weight numeric
@attribute acceleration numeric
@attribute modelyear numeric
@attribute origin numeric

@data
18.0,8,307.0,130.0,3504.,12.0,70,1
14.0,8,455.0,225.0,3086.,10.0,70,1
24.0,4,113.0,95.00,2372.,15.0,70,3
22.0,6,198.0,95.00,2833.,15.5,70,1
27.0,4,97.00,88.00,2130.,14.5,70,3
26.0,4,97.00,46.00,1835.,20.5,70,2
```

... +400 more rows

Thoughtland: Output

- MLP, 2 hidden layers (3, 2 units), acc. 65%, Thoughtland generates:

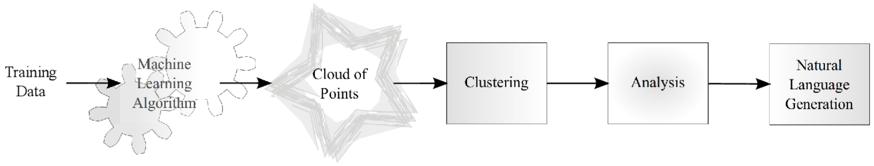
  > *There are four components and eight dimensions. Components One, Two and Three are small. Components One, Two and Three are very dense.* ***Components Four, Three and One are all far from each other.*** *The rest are all at a good distance from each other.*

- MLP, 1 hidden layer (8 units), acc. 65.7%, Thoughtland generates:

  > *There are four components and eight dimensions. Components One, Two and Three are small. Components One, Two and Three are very dense.* ***Components Four and Three are far from each other.*** *The rest are all at a good distance from each other.*

(difference is ***highlighted***)

Thoughtland: Architecture



Summary

- UIMA es un *framework* para procesamiento de información no-estructurada listo para usar en producción.
  - Permite procesamiento por lotes o con muy baja latencia.
- UIMA es un framework y tiene bastante pocos anotadores dentro de él.
  - Pero nuevos anotadores empiezan a estar disponibles a través de OpenNLP y ClearTk.
- Es un *framework* eficiente que requiere bastante trabajo por parte de sus usuarios.
  - La curva de aprendizaje de UIMA es bastante pronunciada.