Insight gaining from OLAP queries via data movies

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Caught somewhere in time

- **Query result = (just) a set of tuples**

- No difference from the 70's when this assumption was established and tailored for
  - what people had available then
    - … a green/orange monochrome screen
    - … a dot-matrix(?) printer
    - … nothing else
  - users being programmers

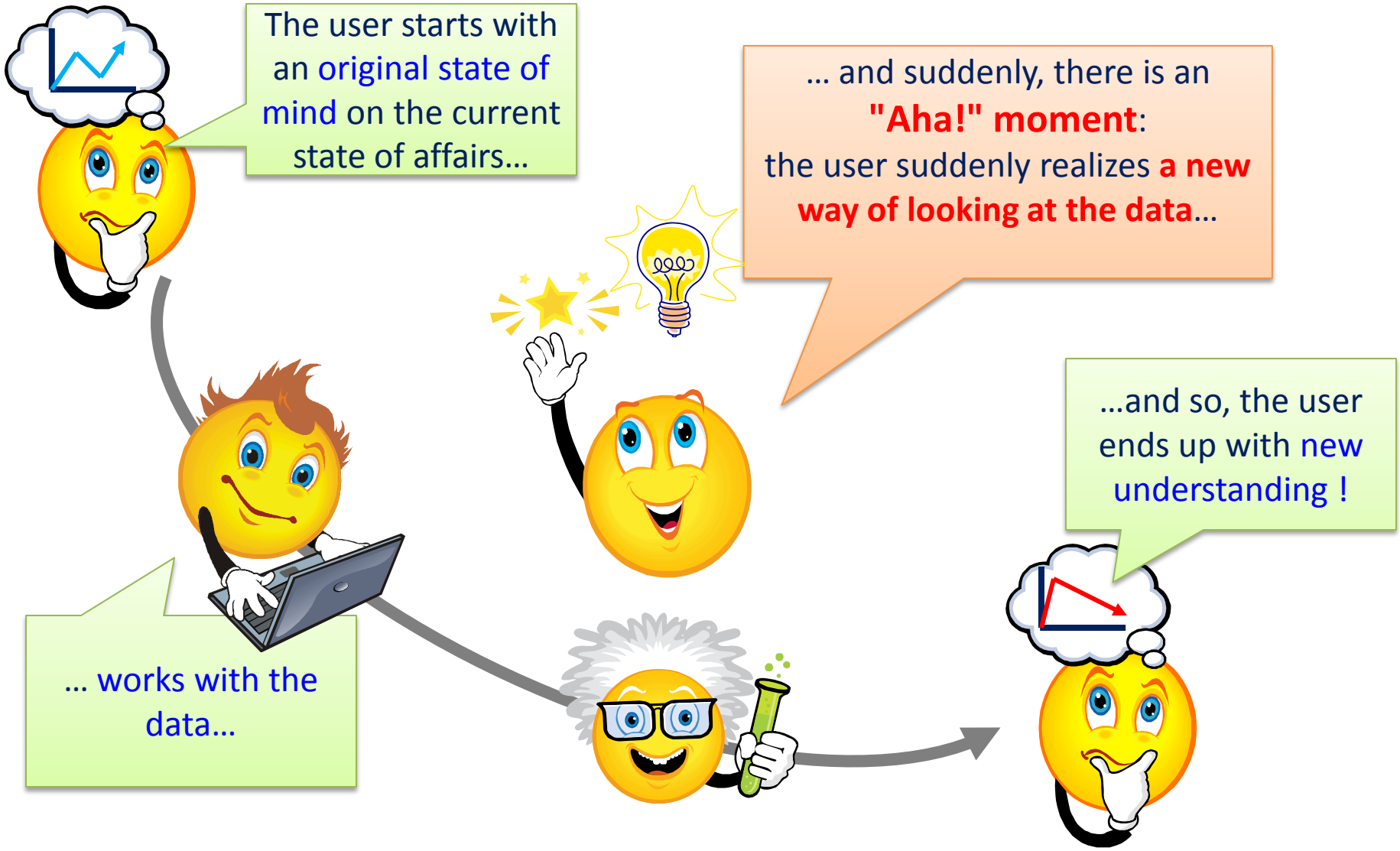
Photos copied from http://en.wikipedia.org/

So far, database systems assume their work is done once results are produced, effectively prohibiting even well-educated end-users to work with them.

No more just sets of tuples …

REPLACE QUERY ANSWERING WITH INSIGHT GAINING!

Insight gaining: Aha! moments



Replace query answering with insight gaining!

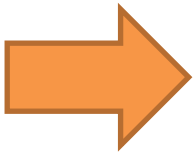
- What is **insight**?
  - InfoVis community: "something that is gained" (after the observation of data by a participant)
  - Psychologists:"Aha!" moment which is experienced

- A combined view:
  1. the user starts with an original state of mind on the current state of affairs
  2. there is an "Aha!" moment where the user suddenly realizes a new way of looking at the data.
  3. resulting in a new mental model for the state of affairs, or else, new understanding

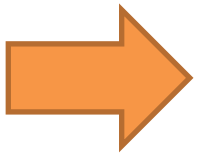
G. Dove. S. Jones. Narrative visualization: Sharing insights into complex data -- available at http://openaccess.city.ac.uk/1134/

… and this is how naïve query answering will be replaced by insight gaining via data analysis …

- Data contextualization
  - contextualize
- (On-line) Pattern Mining & Forecasting
  - extract relationships and patterns
  - generalize for insight
  - confirm hypotheses and errors
- Presentation (share with others for actionable decisions)
  - … but how? … -- see next –



Data analysis: see P. Hanrahan's keynote @SIGMOD'12



… explaining the presentation via data movies

We should and can produce query results that are

- properly visualized
- enriched with textual comments
- vocally enriched

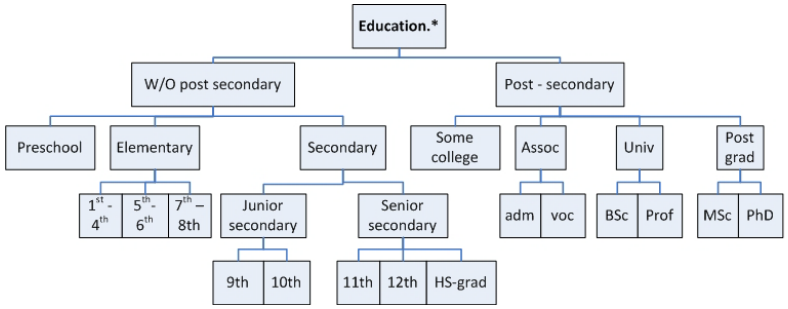
… but then, you have a data movie

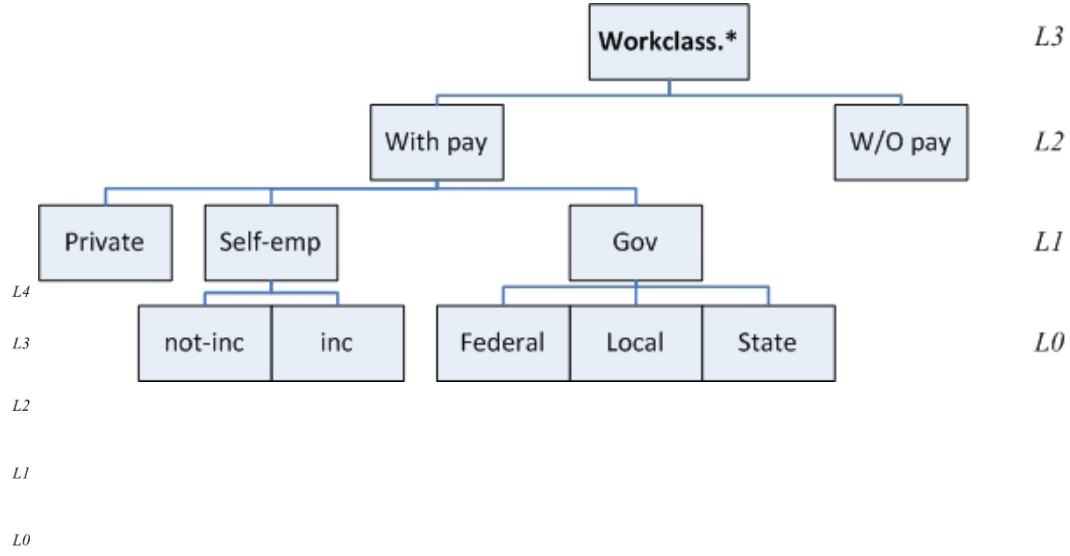
Goal and main idea

- **Goal**: produce **small stories -- data movies** to answer the data worker's query
- **Means**: the CineCubes system and method to orthogonally combine the following tasks:
  - expand a query result with the results of complementary queries which allow the user to contextualize and analyze the information content of the original query.
  - extract meaningful, important patterns, or "highlights" from the query results
  - present the results (a) properly visualized; (b) enriched with an automatically extracted text that comments on the result; (c) vocally enriched, i.e., enriched with audio that allows the user not only to see. but also hear

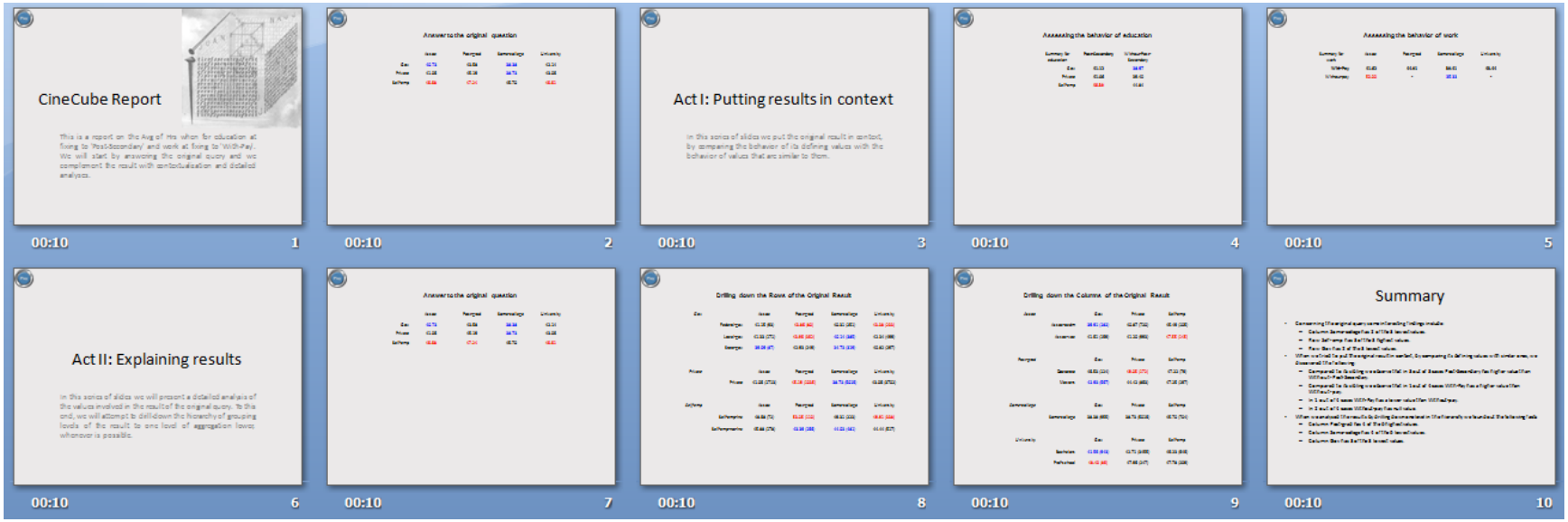
Example

- Find the average work hours per week
  - For persons with *//selection conditions*
    - work_class.level2='With-Pay' . and
    - education.level3= 'Post-Sec'
  - Grouped per *//groupers*
    - work_class.level1
    - education.level3





Example: Result



Answer to the original question

	Assoc	Post-grad	Some-college	University
Gov	40.73	43.58	38.38	42.14
Private	41.06	45.19	38.73	43.06
Self-emp	46.68	47.24	45.70	46.61

Here, you can see the answer of the original query. You have specified education to be equal to 'Post-Secondary', and work to be equal to 'With-Pay'. We report on Avg of work hours per week grouped by education at level 2. and work at level 1 .
You can observe the results in this table. We highlight the largest values with red and the lowest values with blue color.
Column Some-college has 2 of the 3 lowest values.
Row Self-emp has 3 of the 3 highest values.
Row Gov has 2 of the 3 lowest values.

Contributions

- We create a **small "data movie" that answers an OLAP query**
- We complement each query with auxiliary queries organized in thematically related acts that allow us to assess and explain the results of the original query
- We implemented an extensible palette of highlight extraction methods to find interesting patterns in the result of each query
- We describe each highlight with text
- We use TTS technology to convert text to audio

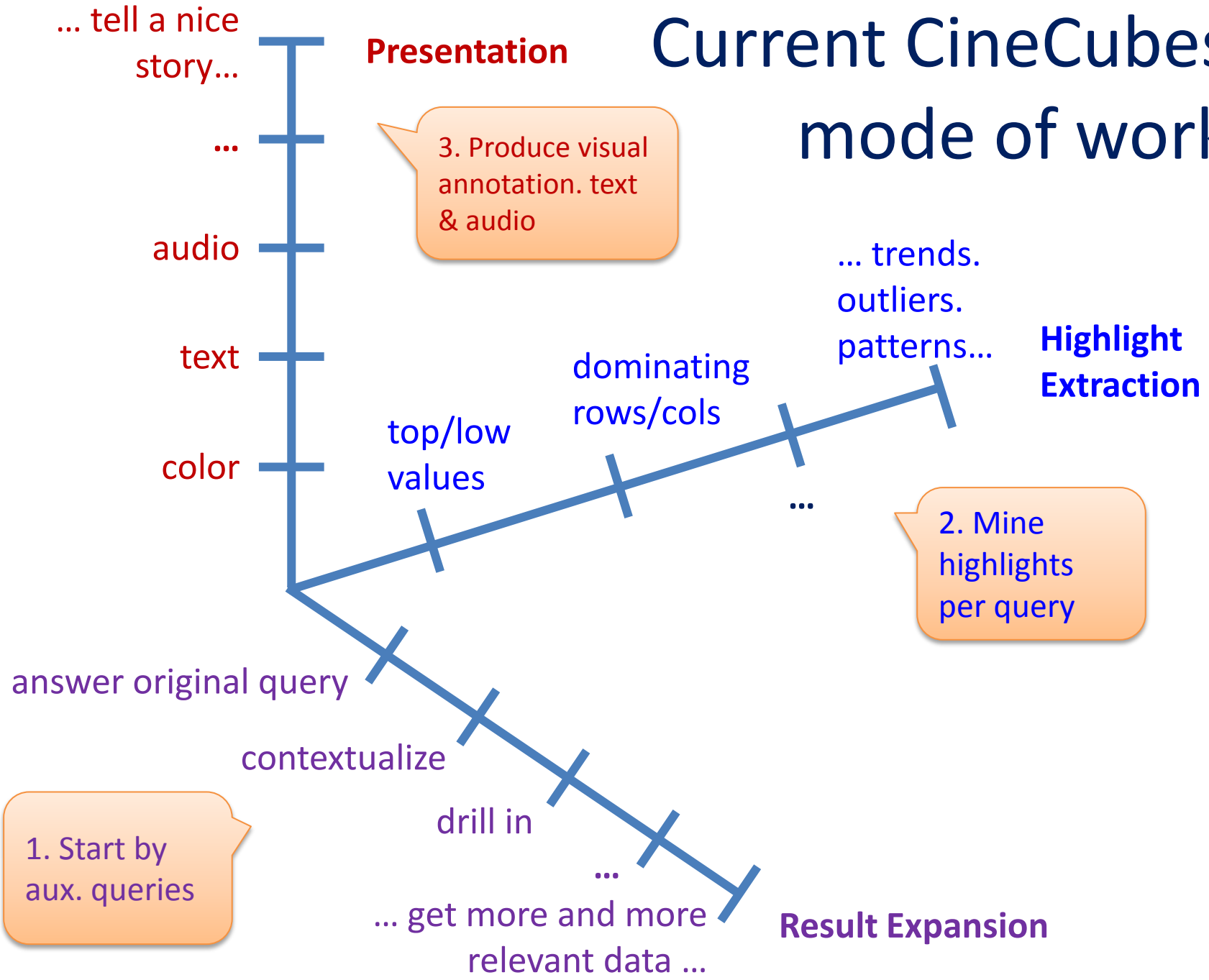
Contributions

- Equally importantly:
  - An extensible software where algorithms for query generation and highlight extraction can be plagued in
  - The demonstration of low technical barrier to produce CineCube reports

Method Overview
Software Issues
Experiments and User Study
Discussion

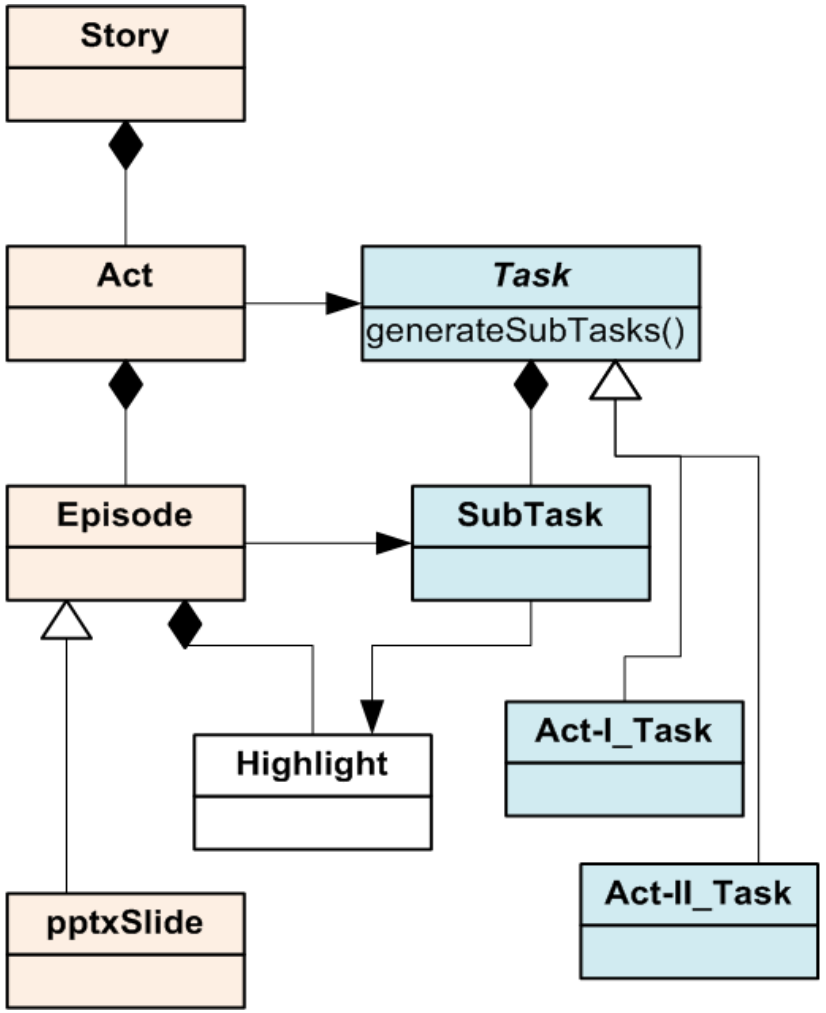
Method Overview

Current CineCubes mode of work



Result expansion: The movie's parts

- Much like movie stories, we organize our stories in acts
- Each act includes several episodes all serving the same purpose
- Tasks provide the machinery to produce results for episodes



Structure of the CineCube Movie

- We organize the CineCube Movie in five Acts:
  - Intro Act
  - Original Act
  - Act I
  - Act II
  - Summary Act

1

	Assoc	Post-grad	Some-college	University
Gov	40.73	43.58	38.38	42.14
Private	41.06	45.19	38.73	43.06
Self-emp	46.68	47.24	45.70	46.61

Original query

Here, you can see the answer of the original query. You have specified education to be equal to 'Post-Secondary', and work to be equal to 'With-Pay'. We report on Avg of Hrs grouped by education at level 2, and work at level 1. We highlight the largest values with red and the lowest values with blue.
Column Some-college has 2 of the 3 lowest values.
Row Self-emp has 3 of the 3 highest values.
Row Gov has 2 of the 3 lowest values.

2

	Post-Secondary	Without Post-Secondary
Gov	**41.12**	38.97
Private	**41.06**	39.40
Self-emp	**46.39**	44.84

Summary for education

In this graphic, we put the original request in context by comparing the value 'Post-Secondary' for education at level 3 with its sibling values. We calculate the Avg of Hrs while fixing education at level 4 to be equal to "ALL", and work at level 2 to be equal to "With-Pay'. We highlight the reference cells with bold, the highest value with red and the lowest value with blue.
Compared to its sibling we observe that in 3 out of 3 cases Post-Secondary has higher value than Without-Post-Secondary.

Act I (sl. 2,3)

In this slide, we drill-down one level for all values of dimension work at level 0. For each cell we show both the Avg of Hrs and the number of tuples that correspond to it in parentheses. ...
Column Post-grad has 4 of the 6 highest values.
Column Some-college has 4 of the 6 lowest values.

3

	Assoc	Post-grad	Some-college	University
With-Pay	**41.62**	**44.91**	**39.41**	**43.44**
Without-pay	50.00	-	35.33	-

Summary for work

Drilling down education

5

Assoc		Gov	Private	Self-emp
	Assoc-acdm	39.91 (182)	40.87 (720)	45.49 (105)
	Assoc-voc	41.61 (169)	41.20 (993)	47.55 (145)
Post-grad		Gov	Private	Self-emp
	Doctorate	46.53 (124)	49.05 (172)	47.22 (79)
	Masters	42.93 (567)	44.42 (863)	47.25 (197)
Some-college		Gov	Private	Self-emp
	Some-college	38.38 (955)	38.73 (5016)	45.70 (704)
University		Gov	Private	Self-emp
	Bachelors	41.56 (943)	42.71 (3455)	46.23 (646)
	Prof-school	48.40 (86)	47.96 (247)	47.78 (209)

Act II (sl. 3,4)

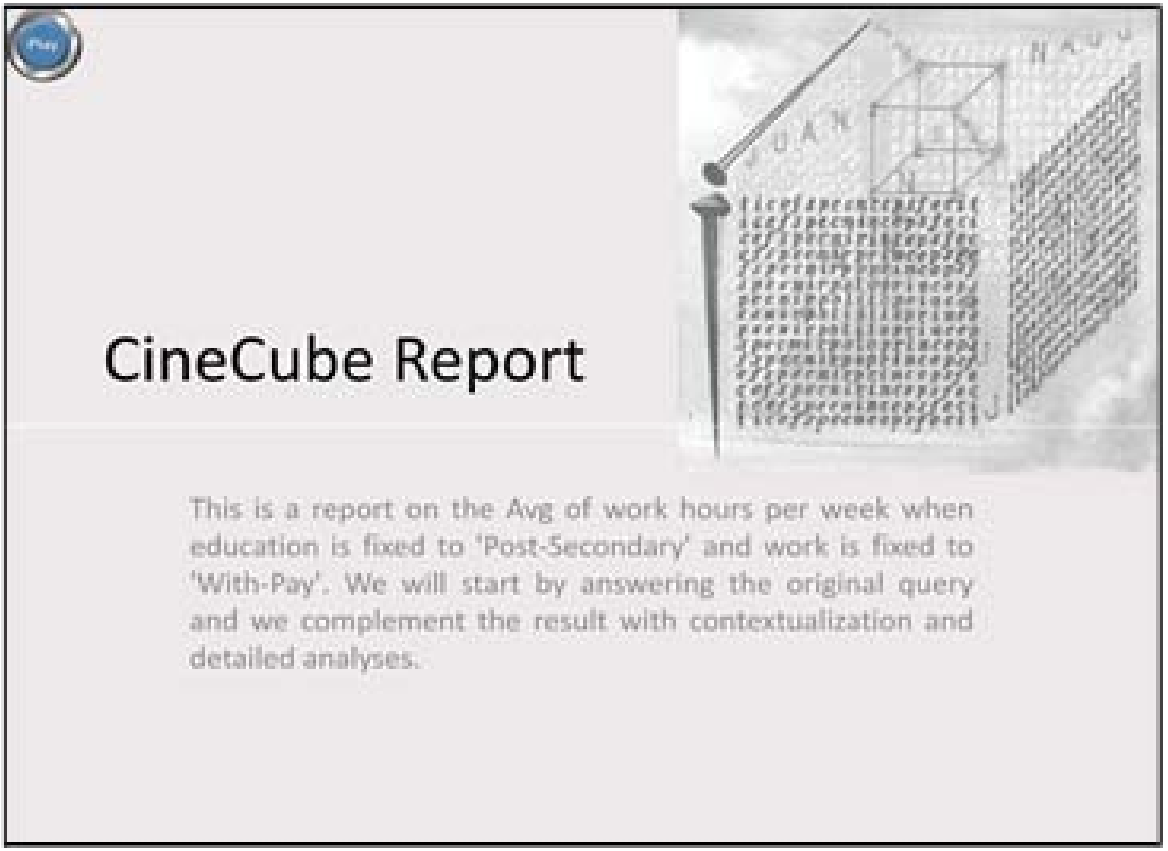
Drilling down work

4

Gov		Assoc	Post-grad	Some-college	University
	Federal-gov	41.15 (93)	43.86 (80)	40.31 (251)	43.38 (233)
	Local-gov	41.33 (171)	43.96 (362)	40.14 (385)	42.34 (499)
	State-gov	39.09 (87)	42.93 (249)	34.73 (319)	40.82 (297)
Private		Assoc	Post-grad	Some-college	University
	Private	41.06 (1713)	45.19 (1035)	38.73 (5016)	43.06 (3702)
Self-emp		Assoc	Post-grad	Some-college	University
	Self-emp-inc	48.68 (72)	53.05 (110)	49.31 (223)	49.91 (338)
	Self-emp-not-inc	45.88 (178)	43.39 (166)	44.03 (481)	44.44 (517)

CineCube Movie – Intro Act

- Intro Act has an episode that introduce the story to user



CineCube Movie – Original Act

- Original Act has an episode which is the answer of query that submitted by user

CineCube Movie – Act I

- In this Act we try to answer the following question:
  - How good is the original query compared to its siblings?
- We compare the marginal aggregate results of the original query to the results of "sibling" queries that use "similar" values in their selection conditions

Act I – Example

Result of Original Query

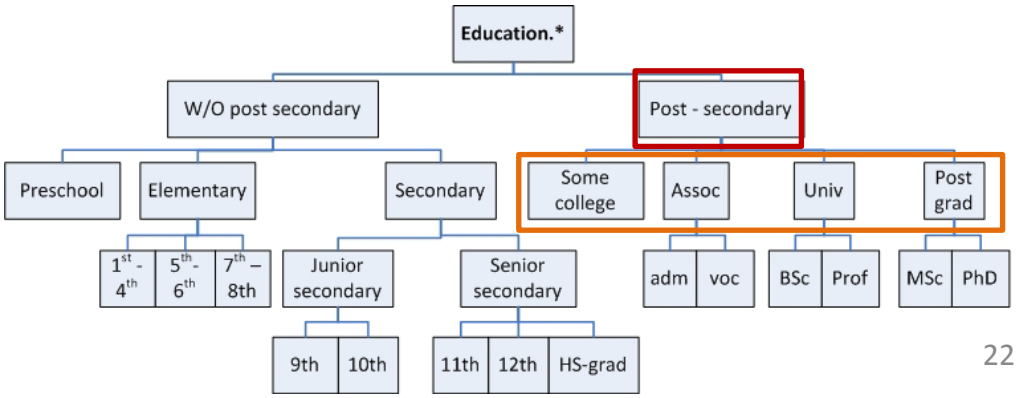
	Assoc	Post-grad	Some-college	University
Gov	40.73	43.58	38.38	42.14
Private	41.06	45.19	38.73	43.06
Self-emp	46.68	47.24	45.70	46.61

$q=(DS^0,$
$W.L_2 =$'With-Pay' $\wedge$ $E.L_3=$'Post-Sec',
$[W.L_1, E.L_2]$,
avg(Hrs))

Assessing the behavior of education

Summary for education	**Post-Secondary**	Without-Post-Secondary
Gov	**41.12**	38.97
Private	**41.06**	39.40
Self-emp	**46.39**	44.84

$q=(DS^0,$
$W.L_2 =$'With-Pay' $\wedge$ $E.L_4=$'All',
$[W.L_1, E.L_3]$,
avg(Hrs))



Act I – Example

Result of Original Query

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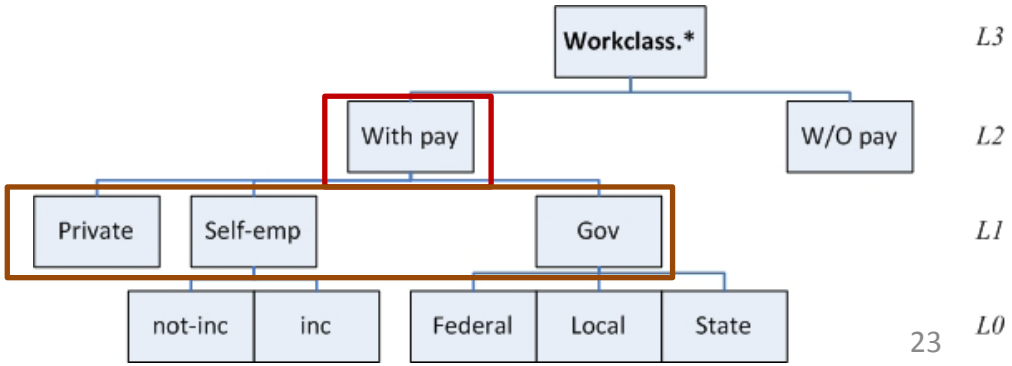
Gov	40.73	43.58	38.38	42.14
Private	41.06	45.19	38.73	43.06
Self-emp	46.68	47.24	45.70	46.61

$q=(DS^0,$
$W.L_2 = \text{'With-Pay'} \wedge E.L_3 = \text{'Post-Sec'},$
$[W.L_1, E.L_2],$
avg(Hrs))

Assessing the behavior of work

Summary for work	Assoc	Post-grad	Some-college	University
With-Pay	**41.62**	**44.91**	**39.41**	**43.44**
Without-pay	50.00	-	35.33	-

$q=(DS^0,$
$W.L_3 = \text{'All'} \wedge E.L_3 = \text{'Post-Sec'},$
$[W.L_2, E.L_2],$
avg(Hrs))



CineCube Movie – Act II

- In this Act we try to explaining to why the result of original query is what it is.
  - "Drilling into the breakdown of the original result"

- We drill in the details of the cells of the original result in order to inspect the internals of the aggregated measures of the original query.

Act II – Example

Result of Original Query

	Assoc	Post-grad	Some-college	University
Gov	40.73	43.58	38.38	42.14
Private	41.06	45.19	38.73	43.06
Self-emp	46.68	47.24	45.70	46.61

$q = (DS^0,$
$W.L_2 = \text{'With-Pay'} \wedge E.L_3 = \text{'Post-Sec'},$
$[W.L_1, E.L_2],$
$\text{avg(Hrs)})$

Drilling down the Rows of the Original Result

Gov		Assoc	Post-grad	Some-college	University
	Federal-gov	41.15 (93)	43.86 (80)	40.31 (251)	43.38 (233)
	Local-gov	41.33 (171)	43.96 (362)	40.14 (385)	42.34 (499)
	State-gov	39.09 (87)	42.93 (249)	34.73 (319)	40.82 (297)
Private					
	Private	41.06 (1713)	45.19 (1035)	38.73 (5016)	43.06 (3702)
Self-emp					
	Self-emp-inc	48.68 (72)	53.05 (110)	49.31 (223)	49.91 (338)
	Self-emp-not-inc	45.88 (178)	43.39 (166)	44.03 (481)	44.44 (517)

Act II – Example

Result of Original Query

	Assoc	Post-grad	Some-college	University
Gov	40.73	43.58	38.38	42.14
Private	41.06	45.19	38.73	43.06
Self-emp	46.68	47.24	45.70	46.61

$q=(DS^0,$
$W.L_2 =$'With-Pay' $\wedge$ $E.L_3=$'Post-Sec',
$[W.L_1, E.L_2],$
avg(Hrs))

Drilling down the Columns of the Original Result

Assoc		Gov	Private	Self-emp
	Assoc-acdm	39.91 (182)	40.87 (720)	45.49 (105)
	Assoc-voc	41.61 (169)	41.20 (993)	47.55 (145)
Post-grad				
	Doctorate	46.53 (124)	49.05 (172)	47.22 (79)
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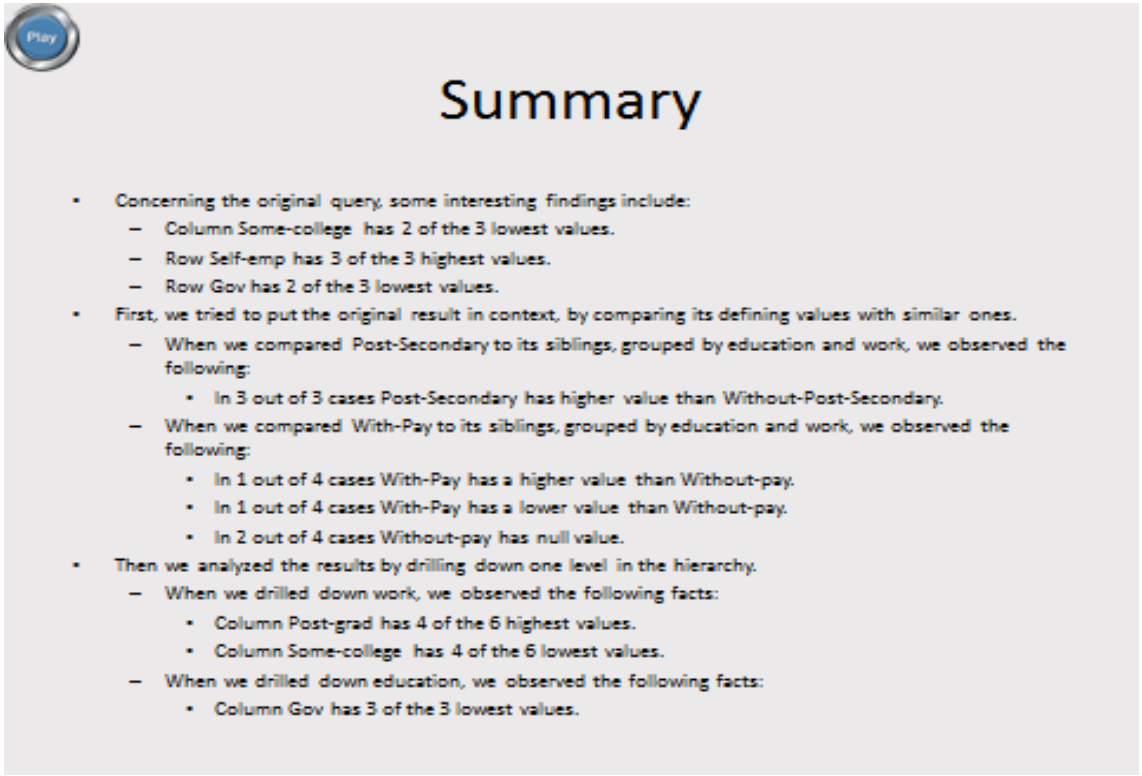
CineCube Movie – Summary Act

- Summary Act represented from one episode.
- This episode has all the highlights of our story.



Highlight Extraction

- We utilize a palette of highlight extraction methods that take a 2D matrix as input and produce important findings as output.
- Currently supported highlights:
  - The top and bottom quartile of values in a matrix
  - The absence of values from a row or column
  - The domination of a quartile by a row or a column
  - The identification of min and max values

Text Extraction

- Text is constructed by a Text Manager that customizes the text per Act
- Text comes from templates, coded
  - for the slides of each act
  - for each highlight extraction algorithm

- **Example**:

  In this slide, we drill-down one level for all values of dimension <dim> at level <l>. For each cell we show both the <agg> of <measure> and the number of tuples that correspond to it.

Textual annotation of the original question

	Assoc	Post-grad	Some-college	University
Gov	40.73	43.58	38.38	42.14
Private	41.06	45.19	38.73	43.06
Self-emp	46.68	47.24	45.70	46.61

Contextualization text coming with the task

Here, you can see the answer of the original query. You have specified education to be equal to 'Post-Secondary', and work to be equal to 'With-Pay'. We report on Avg of work hours per week grouped by education at level 2, and work at level 1 .
You can observe the results in this table. We highlight the largest values with red and the lowest values with blue color.

One sentence per highlight

Column Some-college has 2 of the 3 lowest values.
Row Self-emp has 3 of the 3 highest values.
Row Gov has 2 of the 3 lowest values.

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Software Issues
Experiments and User Study
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Software Issues

Low technical barrier

- Our tool is extensible
  - We can add new tasks to generate complementary queries easily
  - We can add new highlight algorithms to produce highlights easily
- Supportive technologies are surprisingly easier to use
  - Apache POI for pptx generation
  - TTS for text to speech conversion

Apache POI for pptx

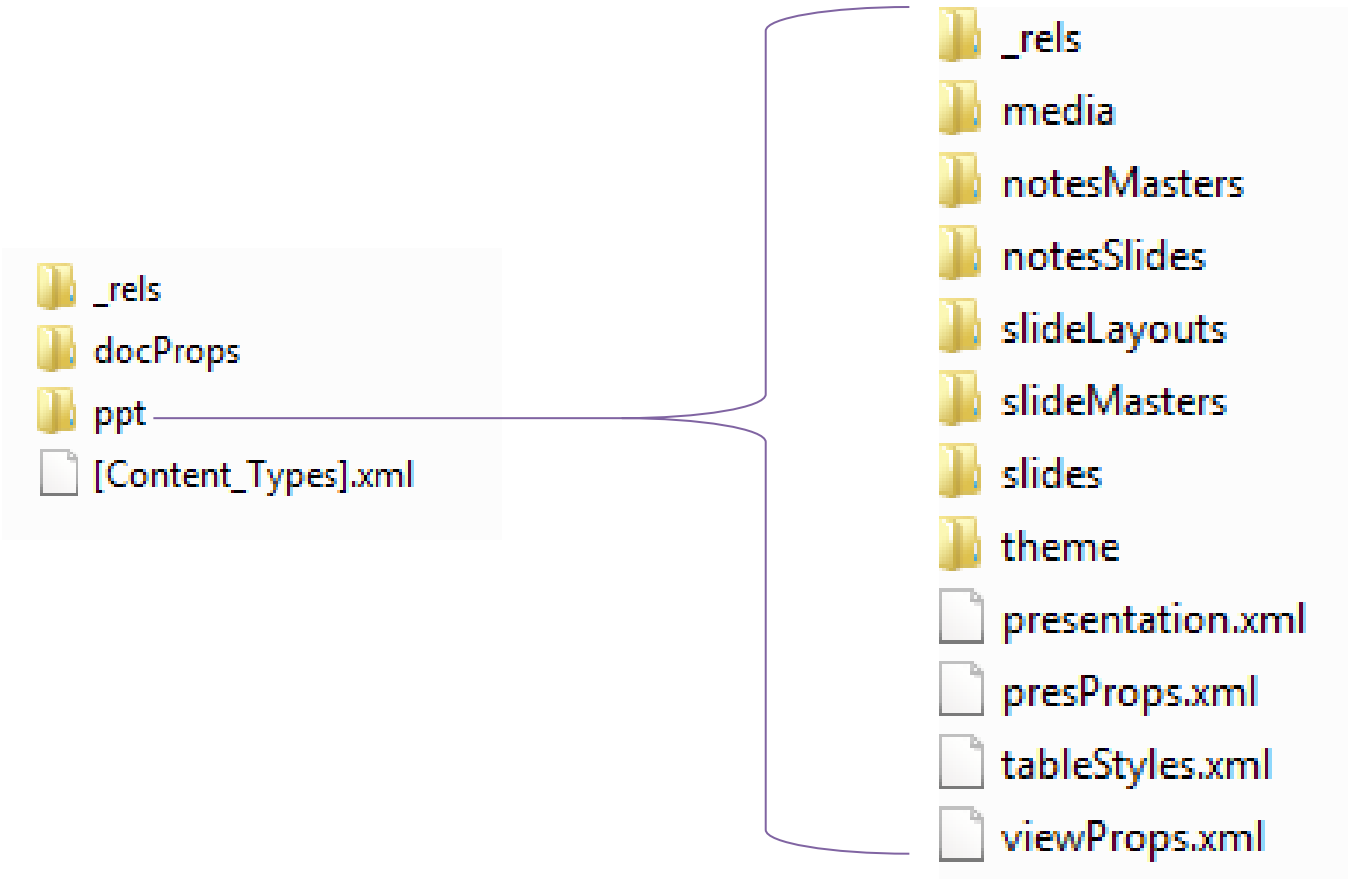
- A Java API that provides several libraries for Microsoft Word. PowerPoint and Excel (since 2001).
- XSLF is the Java implementation of the PowerPoint 2007 OOXML (.pptx) file format.

```
XMLSlideShow ss = new XMLSlideShow();
XSLFSlideMaster sm = ss.getSlideMasters()[0];

XSLFSlide sl= ss.createSlide
(sm.getLayout(SlideLayout.TITLE_AND_CONTENT));

XSLFTable t = sl.createTable();
t.addRow().addCell().setText(“added a cell”);
```

PPTX Folder Structure



MaryTTS for Text-to-Speech Synthesis

```
MaryInterface m = new LocalMaryInterface();
m.setVoice(“cmu-slt-hsmm”);

AudioInputStream audio = m.generateAudio("Hello”);

AudioSystem.write(audio. audioFileFormat.Type.WAVE.
new File(“myWav.wav”));
```

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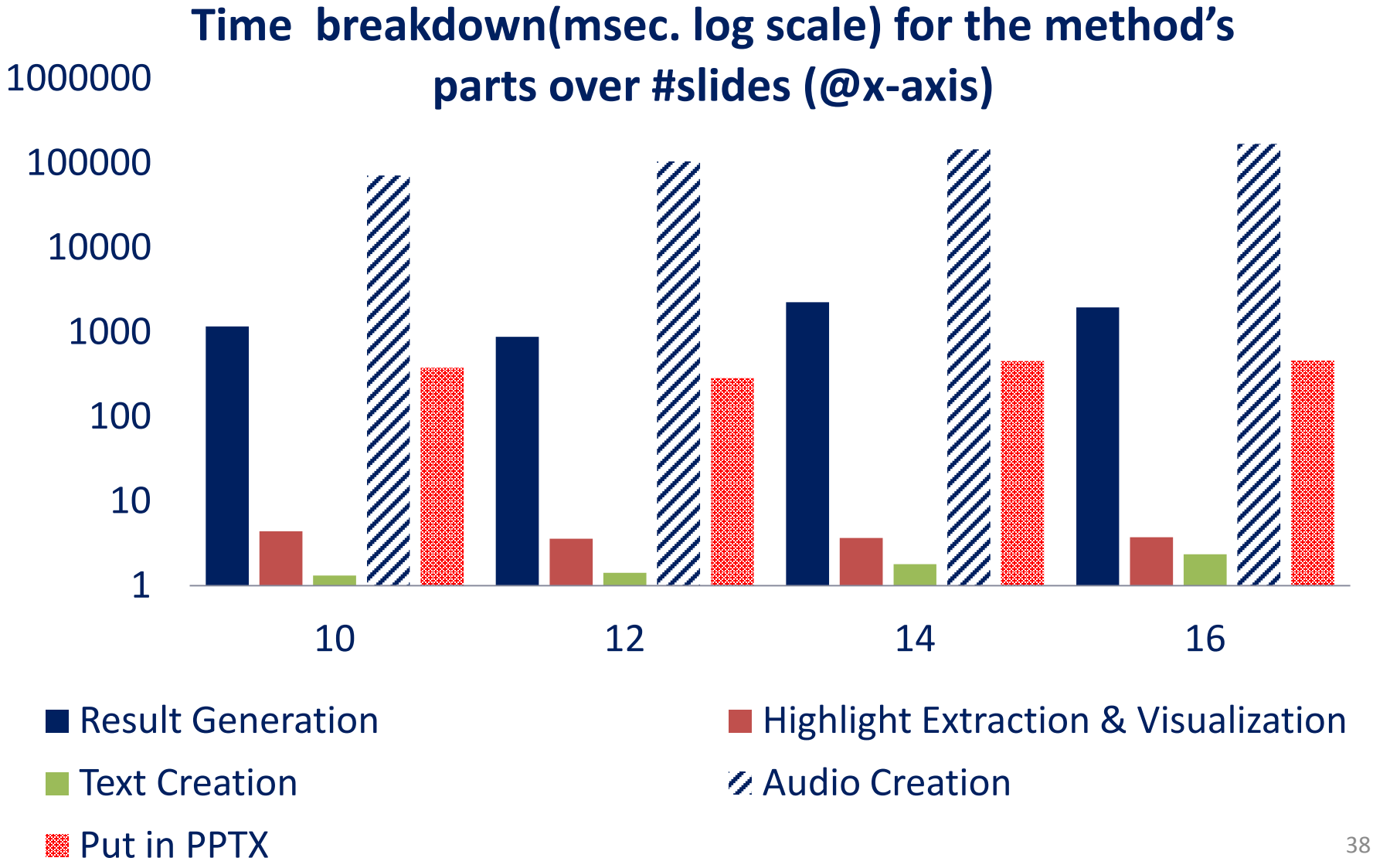
Experiments

Experimental setup

- Adult dataset referring to data from 1994 USA census
  - Has 7 dimension Age, Native Country, Education, Occupation, Marital status, Work class, and Race.
  - One Measure : work hours per week
- Machine Setup :
  - Running Windows 7
  - Intel Core Duo CPU at 2.50GHz.
  - 3GB main memory.

Experimental Results



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User Study

User Study Setup

- Goal: compare the effectiveness of CineCubes to simple OLAP
- Opponent: we constructed a simple system answering aggregate queries in OLAP style
- Participants: 12 PhD students from our Department. all of which were experienced in data management and statistics.

Experiment in 4 phases

- Phase 0 – Contextualization: users were introduced to the data set and the tools.
- Phase 1 – Work with simple OLAP: we asked the users to prepare a **report** on a specified topic via a simple OLAP tool. The report should contain
  - a bullet list of key, highlight findings,
  - a text presenting the overall situation, and,
  - optionally, any supporting statistical charts and figures to elucidate the case better

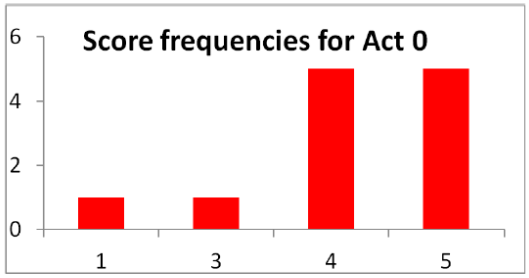
Experiment in 4 phases

- Phase 2 – work with CineCubes: prepare a report on the same topic, but now, **with** CineCubes.
- Phase 3 - evaluation: Once the users had used the two systems, they were asked to complete a questionnaire with:
  - information for the time (efficiency) needed to complete their reports.
  - an assessment in a scale of 1 to 5 (effectiveness) of
    - the usefulness of the different acts of the CineCubes report.
    - the usefulness of the textual parts and the voice features of CineCubes
    - the quality of the two reports after having produced both of them.

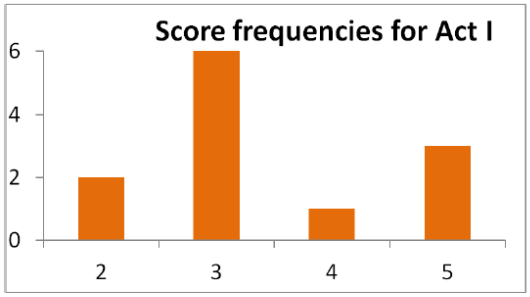
Usefulness of CineCubes' parts

- The users were asked to assess the usefulness of the parts of CineCubes in a scale of 1 (worst) to 5 (best)
- All features scored an average higher than 3.
- Users appreciated differently the different acts and parts of the system
  - **Likes: Drilling down (Act II), color + highlight + text**
  - OK: contextualization (Act I), Summary, audio

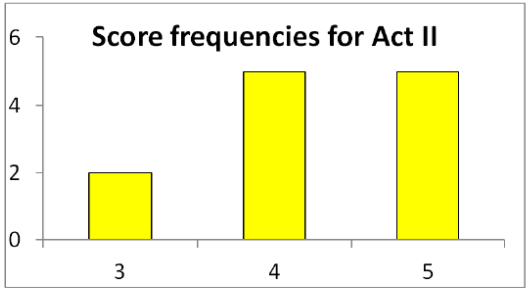
Usefulness of CineCubes' parts



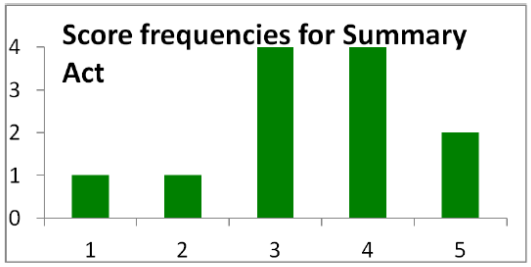
Original query



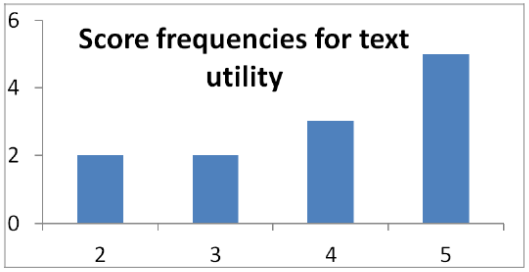
Act I



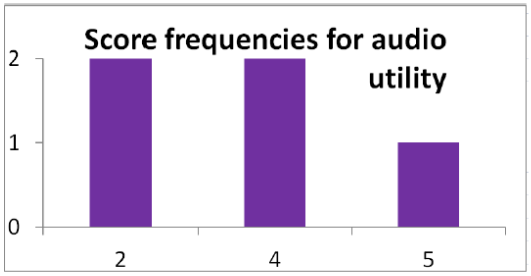
Act II



Summary



Text



Audio (if used)

Popular features

- The most popular feature: Act II, with the detailed, drill-down analysis of the groupers.
  - ...giving information enlarging the picture of the situation that was presented to users & worth including at the report.
- Second most popular feature: the treatment of the original query (that includes coloring and highlight extraction compared to the simple query results given to them by the simple querying system).

The less appreciated parts

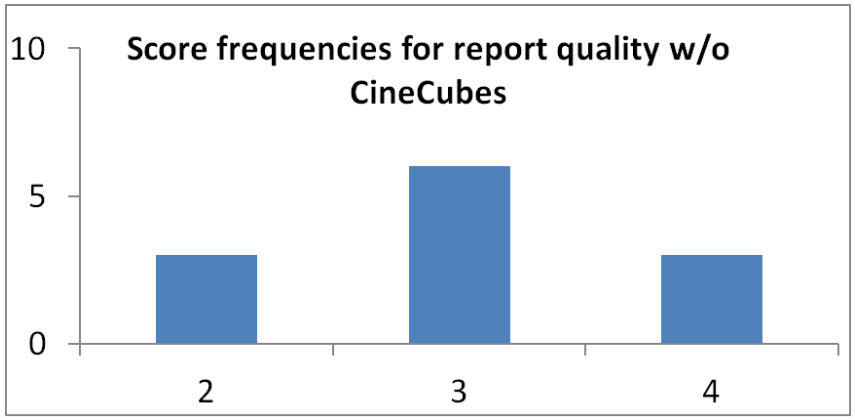
- The less appreciated parts were:
  - Act I (which contextualizes the result by comparing it to similar values)
  - summary act (presenting all the highlights in a single slide).

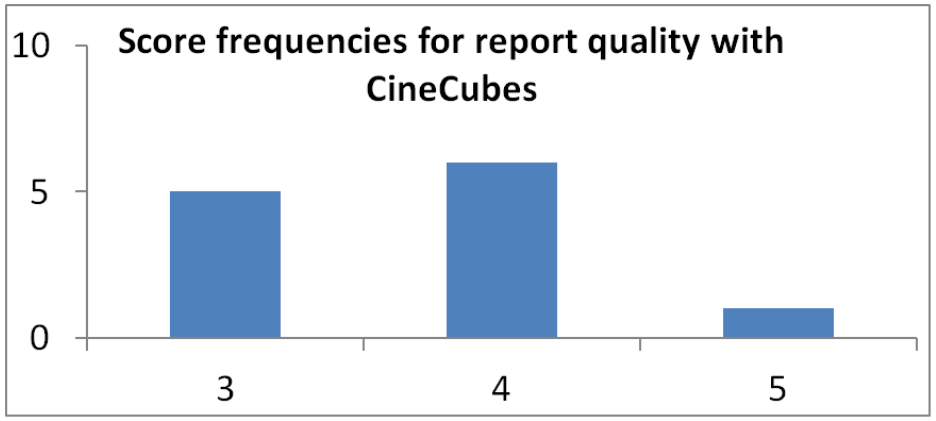
- Why? The contextualization and the summary acts provide too much information (and in fact, too many highlights).
- **Lesson learned: above all, be concise!**

Text and audio

- The textual part was quite appreciated by most of the users.
- Out of 5 users that worked with audio, the result was split in half in terms of likes and dislikes. Due to...
  - ... the quality of the produced audio by the TTS, and,
  - the quality of the text that is served to it as input.
- Lesson learned: audio seems to be useful for some users but not for all
  - … so, it should be optional, which can provide gains in terms of efficiency without affecting effectiveness.

Report quality





Quality of the report improves with CineCubes:

- the distribution is shifted by one star upwards, with the median shifting from 3 to 4.
- the average value raised from 3 to 3.7 (23% improvement)

The free-form comments indicated that the score would have been higher if the tool automatically produced graphs and charts (an issue of small research but high practical value).

Time and quality considerations

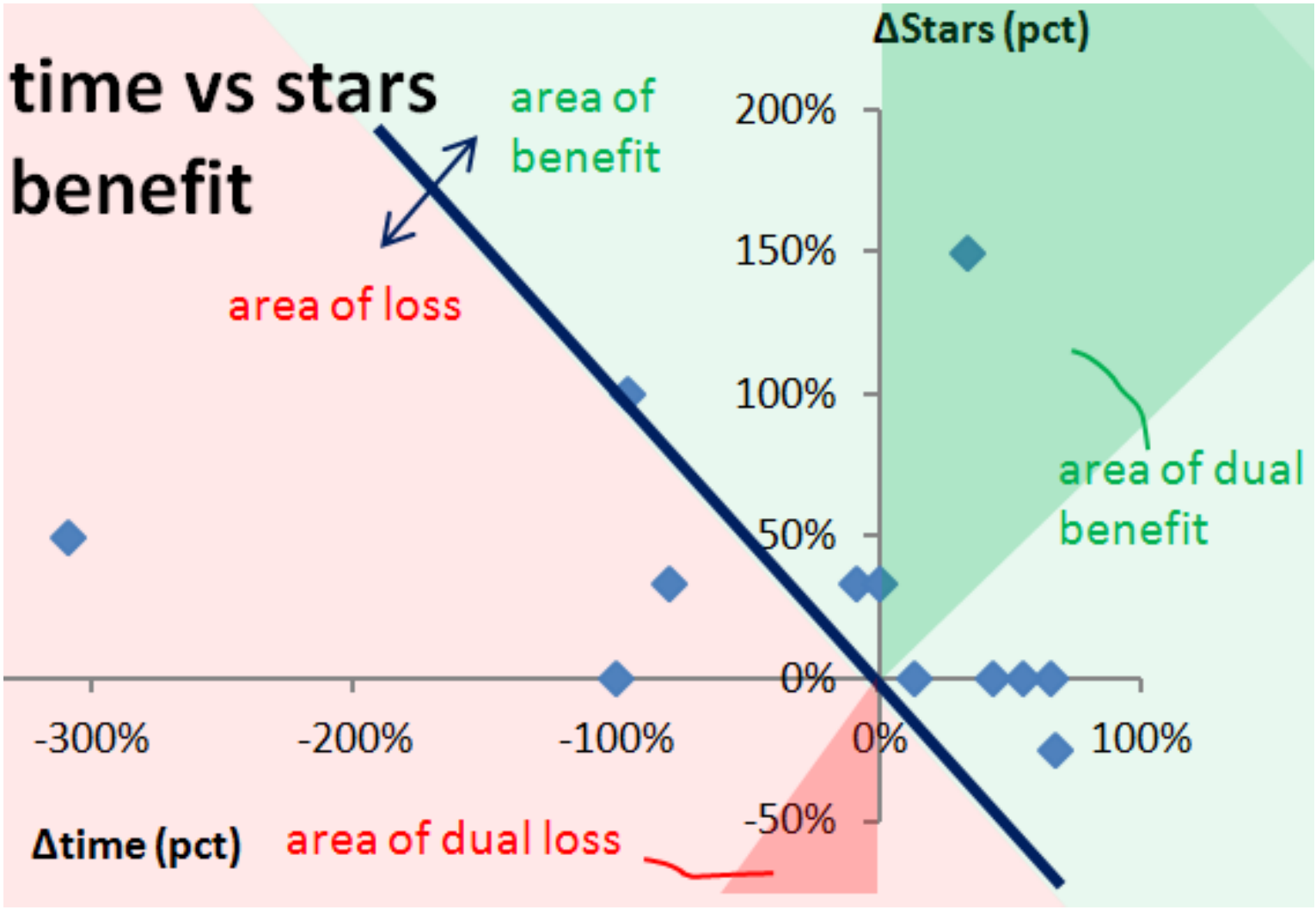
- Are there any speed-ups in the work of the users if they use CineCubes?
- … or more realistically …
- Does it pay off to spend more time working with the system for the quality of the report one gets?

Benefit in time vs Benefit in quality

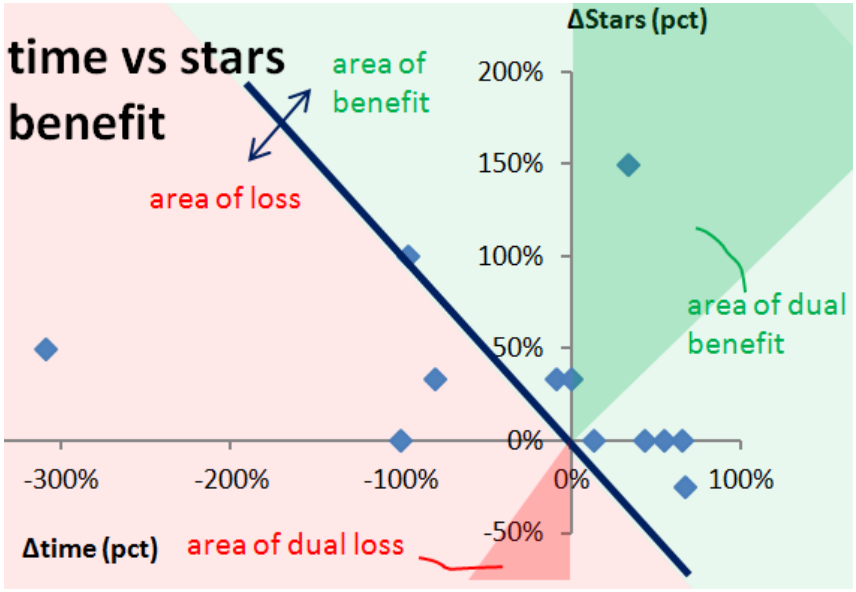
User Id	Time to complete report (mins) w/o CC	with CC	Δtime	pct Δtime	Quality of Report (stars) w/o CC	with CC	ΔStars	pct Δstars
3	10	20	-10	-100,00%	3	3	0	0,00%
4	11	45	-34	-309,09%	2	3	1	50,00%
2	23	45	-22	-95,65%	2	4	2	100,00%
5	23	25	-2	-8,70%	3	4	1	**33,33%**
21	25	45	-20	-80,00%	3	4	1	**33,33%**
8	25	25	0	0,00%	3	4	1	**33,33%**
12	30	26	4	13,33%	4	4	0	0,00%
17	60	40	20	33,33%	2	5	3	150,00%
6	70	40	30	42,86%	4	4	0	0,00%
1	71	25	46	64,79%	3	3	0	0,00%
15	100	45	55	55,00%	3	3	0	0,00%
16	105	35	70	66,67%	4	3	-1	-25,00%

table rows are **sorted** by the time needed **w/o CC**

Benefit in time vs Benefit in quality



Lessons learned



User Id	Time to complete report (mins) w/o CC	with CC	Δtime	pct Δtime	Quality of Report (stars) w/o CC	with CC	ΔStars	pct Δstars
3	10	20	-10	-100,00%	3	3	0	0,00%
4	11	45	-34	-309,09%	2	3	1	50,00%
2	23	45	-22	-95,65%	2	4	2	100,00%
5	23	25	-2	-8,70%	3	4	1	33,33%
21	25	45	-20	-80,00%	3	4	1	33,33%
8	25	25	0	0,00%	3	4	1	33,33%
12	30	26	4	13,33%	4	4	0	0,00%
17	60	40	20	33,33%	2	5	3	150,00%
6	70	40	30	42,86%	4	4	0	0,00%
1	71	25	46	64,79%	3	3	0	0,00%
15	100	45	55	55,00%	3	3	0	0,00%
16	105	35	70	66,67%	4	3	-1	-25,00%

- For people in need of a fast report
  - **conciseness is key**, as too many results slow them down
  - CineCubes allows these people to create reports of better quality.
- For people who want a quality report, i.e., would be willing to spend more time to author a report in the first place,
  - CineCubes speeds up their work by a factor of 46% in average.

Method Overview
Software Issues
Experiments and User Study
Discussion

Discussion

Extensions

- There are three clear "dimensions" of extensibility, each for a particular dimension of the problem:
  1. what kind of query results (episodes) we collect from the database – which means investigating new acts to add
  2. more highlight extraction algorithms to automatically discover important findings within these results
  3. how do we "dress" the presentation better, with graphs and texts around the highlights

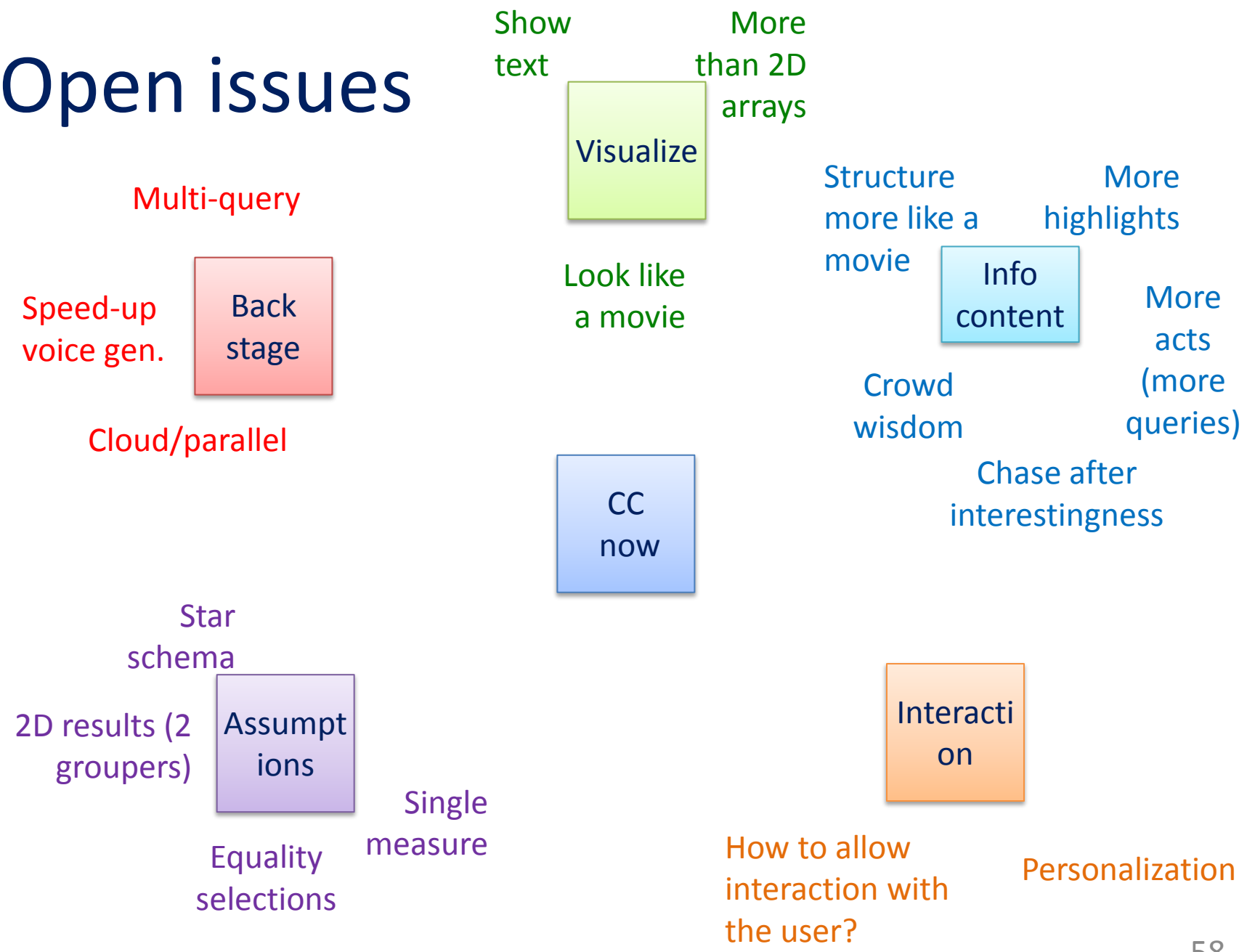
Open Issues

- Can I be the director? Interactively maybe?
  - Interactivity, i.e., the possibility of allowing the user to intervene is challenge, due to the fact that CineCubes is intended to give stories. So, the right balance between interaction and narration has to be found.
- Recommendations. Closely related to interactivity, is the possibility of guiding the subsequent steps of a CineCubes session -- e.g., via user profiles or user logs.
- Efficiency
  - Scale with data size and complexity, in user time
  - Techniques like multi-query optimization have a good chance to succeed, especially since we operate with a known workload of queries as well as under the divine simplicity of OLAP.

Be compendious; if not, at least **be concise**!

- The **single most important challenge** that the problem of answer-with-a-movie faces is the ***identification of what to exclude!***
  - The problem is not to add more and more recommendations or findings (at the price of time expenses): this can be done both effectively (too many algorithms to consider) and efficiently (or, at least, tolerably in terms of user time).
  - The main problem is that it is very hard to keep the story both interesting and informative and, at the same time, automate the discovery of highlights and findings.
- So, **important topics of research** involve
  - the automatic ranking and pruning of highlights
  - the merging of highlights that concern the same data values

Open issues


Show text
More than 2D arrays
Visualize
Look like a movie
Structure more like a movie
More highlights
Info content
More acts (more queries)
Crowd wisdom
Chase after interestingness
Multi-query
Speed-up voice gen.
Back stage
Cloud/parallel
CC now
Star schema
2D results (2 groupers)
Assumpt ions
Single measure
Equality selections
Interacti on
How to allow interaction with the user?
Personalization

Thank you!

Any questions?

More information

- http://www.cs.uoi.gr/~pvassil/projects/cinecubes/

Demo

- http://snf-56304.vm.okeanos.grnet.gr/

Code

- https://github.com/DAINTINESS-Group/CinecubesPublic.git

AUXILIARY SLIDES

Related Work

Related Work

- Query Recommendations
- Database-related efforts
- OLAP-related methods
- Advanced OLAP operators
- Text synthesis from query results

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- Query Recommendations
- Database-related efforts
- OLAP-related methods
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Query Recommendations

- A. Giacometti, P. Marcel, E. Negre, A. Soulet, 2011. Query Recommendations for OLAP Discovery-Driven Analysis. IJDWM 7,2 (2011), 1-25 DOI= http://dx.doi.org/10.4018/jdwm.2011040101

- C. S. Jensen, T. B. Pedersen, C. Thomsen, 2010. Multidimensional Databases and Data Warehousing. Synthesis Lectures on Data Management, Morgan & Claypool Publishers

- A. Maniatis, P. Vassiliadis, S. Skiadopoulos, Y. Vassiliou, G. Mavrogonatos, I. Michalarias, 2005. A presentation model and non-traditional visualization for OLAP. IJDWM, 1,1 (2005), 1-36. DOI= http://dx.doi.org/10.4018/jdwm.2005010101

- P. Marcel, E. Negre, 2011. A survey of query recommendation techniques for data warehouse exploration. EDA (Clermont-Ferrand, France, 2011), pp. 119-134

Database-related efforts

- K. Stefanidis, M. Drosou, E. Pitoura, 2009. "You May Also Like" Results in Relational Databases. PersDB (Lyon, France, 2009).

- G. Chatzopoulou, M. Eirinaki, S. Koshy, S. Mittal, N. Polyzotis, J. Varman, 2011. The QueRIE system for Personalized Query Recommendations. IEEE Data Eng. Bull. 34,2 (2011), pp. 55-60

OLAP-related methods

- V. Cariou, J. Cubillé, C. Derquenne, S. Goutier, F.Guisnel, H. Klajnmic, 2008. Built-In Indicators to Discover Interesting Drill Paths in a Cube. DaWaK (Turin, Italy, 2008), pp. 33-44, DOI=http://dx.doi.org/10.1007/978-3-540-85836-2_4

- A. Giacometti, P. Marcel, E. Negre, A. Soulet, 2011. Query Recommendations for OLAP Discovery-Driven Analysis. IJDWM 7,2 (2011), 1-25 DOI= http://dx.doi.org/10.4018/jdwm.2011040101

Advanced OLAP operators

- Sunita Sarawagi: User-Adaptive Exploration of Multidimensional Data. VLDB 2000:307-316

- S. Sarawagi, 1999. Explaining Differences in Multidimensional Aggregates. VLDB (Edinburgh, Scotland, 1999), pp. 42-53

- G. Sathe, S. Sarawagi, 2001. Intelligent Rollups in Multidimensional OLAP Data. VLDB (Roma, Italy 2001), pp.531-540

Text synthesis from query results

- A. Simitsis, G. Koutrika, Y. Alexandrakis, Y.E. Ioannidis, 2008. Synthesizing structured text from logical database subsets. EDBT (Nantes, France, 2008) pp. 428-439, DOI=http://doi.acm.org/10.1145/ 1353343.1353396

Formalities

OLAP Model

- We base our approach on an OLAP model that involves
  - Dimensions, defined as lattices of dimension levels
  - Ancestor functions, (in the form of $\mathrm{anc}_{L_1}^{L_2}$) mapping values between related levels of a dimension
  - Detailed data sets, practically modeling fact tables at the lowest granule of information
  - Cubes, defined as aggregations over detailed data sets

What is Cube?

- A primary Cube C is described as

$$C=(DS^0,\Phi,[L_1,\dots,L_n,M_1,\dots,M_m],[agg_1(M_1^0),\dots,agg_1(M_m^0)])$$

  - DS^0 is a detailed dataset over the schema
  - Φ is a detailed selection condition
    - Φ analyzed as $\varphi_1 \wedge \cdots \wedge \varphi_k$
    - $\varphi_i \ is \ D_i.L_j = value_i$
  - $L_1,\dots,L_n$ are levels such that $L_i \prec L_{i+1}$, $1 \le i \le n$.
  - $M_1,\dots,M_m$ are measures
  - $agg_i \in \{max, min, sum, count, \text{average}\}$, $1 \le i \le m$

Cube Query

- A cube query Q can be considered as

$$Q=(DS^0,\Sigma,\Gamma,\gamma(M))$$

- where:
  - Σ is a conjunction of dimensional restrictions of the form
  - Γ is a set of grouper dimensional level
  - $\gamma(M)$ is an aggregate function applied to the measure of the cube

Cube Query

- In our approach we assume that the user submit cube queries which denote as:
  - $q=(DS^0, \varphi_1 \wedge \cdots \wedge \varphi_k, [L_\alpha, L_\beta], agg(M))$
- Example:

$q=(A, W.L_2 = \text{'With-Pay'} \wedge E.L_3 = \text{'Post-Sec'}, [W.L_1, E.L_2], avg(Hrs))$

Cube Query to SQL Query

- In general case :

  SELECT $L_1, \dots, L_n, agg_1(M_1^0), \dots, agg_1(M_1^0)])$
  FROM DS^0 INNER JOIN D_1, ...INNER JOIN D_n
  WHERE ϕ
  GROUP BY $L_1, \dots, L_n$

- Example for our case:

  SELECT W.L_1, E.L_2,AVG(Hrs)
  FROM A
  INNER JOIN W ON A.W=W.L_0
  INNER JOIN E ON A.E=E.L_0
  WHERE W.L_2 ='With-Pay' AND E.L_3 ='Post-Sec'
  GROUP BY W.L_1, E.L_2

Method Internals

Act I – Problem

- The average user need to compare on the same screen and visually inspect differences
- But as the number of selection conditions increase so the number of siblings increases.
- It can be too hard to be able to visually compare the results

Act I – Our Definition

- We introduce two marginal sibling queries, one for each aggregator.
- Formally, given an original query:

$$q=(DS^0, \varphi_1 \wedge \cdots \wedge \varphi_k, [L_\alpha, L_\beta], agg(M))$$

- Its two marginal sibling queries are:
  1. $q^s=(DS^0, \varphi_1 \wedge \cdots \varphi_\chi^* \wedge \cdots \wedge \varphi_k, [L_\alpha, L_\chi], agg(M))$
  2. $q^s=(DS^0, \varphi_1 \wedge \cdots \varphi_\chi^* \wedge \cdots \wedge \varphi_k, [L_\chi, L_\beta], agg(M))$
     - $\varphi_\chi^*: L_{x+1} = anc_{L_x}^{L_{x+1}}(v)$

Act I – Query Example

- Original Query
  - q=(DS^0,W.L_2 ='With-Pay' $\wedge$ E.L_3='Post-Sec', [W.L_1, E.L_2], avg(Hrs))
- Sibling Queries:
  1. q=(DS^0,W.L_2='With-Pay' $\wedge$ E.L_4='All', [W.L_1, E.L_3], avg(Hrs))
  2. q=(DS^0,W.L_3 ='All' $\wedge$ E.L_3='Post-Sec', [W.L_2, E.L_2], avg(Hrs))

Act I – How produce it?

- We define a sibling query as a query with a single difference to the original:
  - Instead of an atomic selection formula $L_i = v_i$, the sibling query contains a formula of the form $L_i \in \text{childen}(\text{parent}(v_i))$.
- Formally, given an original query

$$q = (DS^0, \varphi_1 \wedge \cdots \wedge \varphi_k, [L_\alpha, L_\beta], agg(M))$$

- A new query q^s is a sibling query if is of the form

$$q^s = (DS^0, \varphi_1 \wedge \cdots \varphi_\chi^* \wedge \cdots \wedge \varphi_k, [L_\alpha, L_\beta], agg(M))$$

  - $\varphi_\chi^* : L_{x+1} = anc_{L_x}^{L_{x+1}}(v)$

Act II – Query Example

- Original Query
  - q=(DS^0,W.L_2 ='With-Pay' ∧ E.L_3='Post-Sec', [W.L_1, E.L_2], avg(Hrs))
- Drill in Queries for work dimension:
  1. q=(DS^0,W.L_1='Gov' ∧ E.L_3='Post-Sec', [W.L_0, E.L_2], avg(Hrs))
  2. q=(DS^0,W.L_1 ='Private' ∧ E.L_3='Post-Sec', [W.L_0, E.L_2], avg(Hrs))
  3. q=(DS^0,W.L_1 ='Self-emp' ∧ E.L_3='Post-Sec', [W.L_0, E.L_2], avg(Hrs))

For Education dimension: similarly

Act II- How produce it?

- Assume a cube query and its result, visualized as a 2D matrix.
- For each cell c of this result is characterized by the following cube query:
  - $q^c = (DS^0, \phi_1 \wedge \ldots \wedge \phi_k \wedge \phi_c, [L_\alpha, L_\beta], agg(M))$
    - $\varphi_c : L_\alpha = v_a^c \wedge L_\beta = v_\beta^c$

Act II- How produce it?

- For each of the aggregator dimensions, we can generate a set of explanatory drill in queries, one per value in the original result:

1. $q_a^s = (DS^0, \phi_1 \wedge \ldots \wedge \phi_k \wedge \phi, [L_{\alpha-1}, L_\beta], agg(M))$,
2. $q_\beta^s = (DS^0, \varphi_1 \wedge \cdots \wedge \varphi_k \wedge \varphi_c, [L_\alpha, L_{\beta-1}], agg(M))$
   - $\varphi_c : L_\alpha = v_a^c \wedge L_\beta = v_\beta^c$

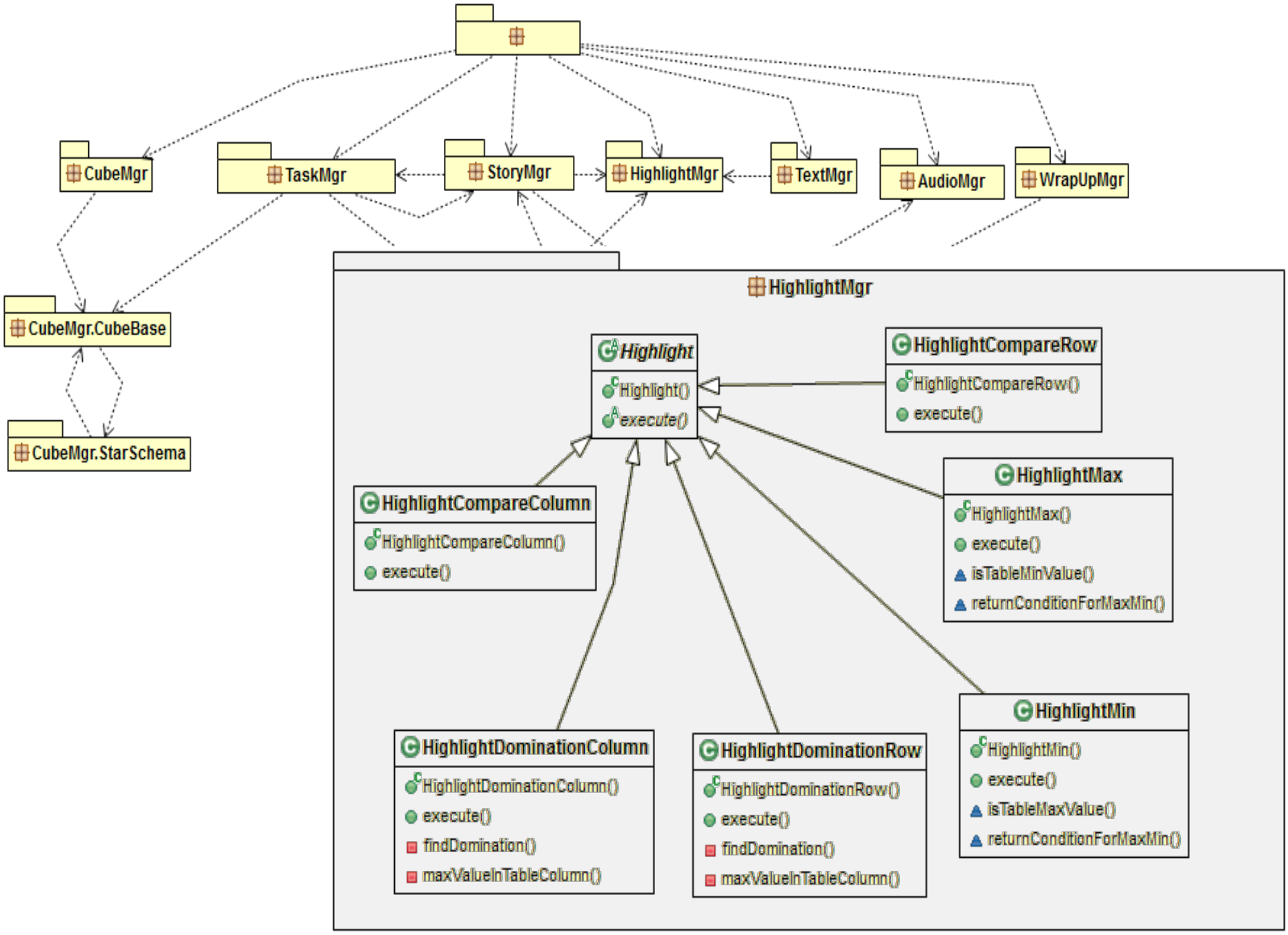
Our Algorithm

Algorithm Construct Operational Act

Input: the original query over the appropriate database

Output: a set of an act's episodes fully computed

1. Create the necessary objects (act, episodes, tasks, subtasks) appropriately linked to each other
2. Construct the necessary queries for all the subtasks of the Act, execute them, and organize the result as a set of aggregated cells (each including its coordinates, its measure and the number of its generating detailed tuples)
3. For each episode
   - Calculate the cells' highlights
   - Calculate the visual presentation of cells
   - Produce the text based on the highlights
   - Produce the audio based on the text


CubeMgr
TaskMgr
StoryMgr
HighlightMgr
TextMgr
AudioMgr
WrapUpMgr
CubeMgr.CubeBase
CubeMgr.StarSchema
HighlightMgr
Highlight
Highlight()
execute()
HighlightCompareRow
HighlightCompareRow()
execute()
HighlightCompareColumn
HighlightCompareColumn()
execute()
HighlightMax
HighlightMax()
execute()
isTableMinValue()
returnConditionForMaxMin()
HighlightDominationColumn
HighlightDominationColumn()
execute()
findDomination()
maxValueInTableColumn()
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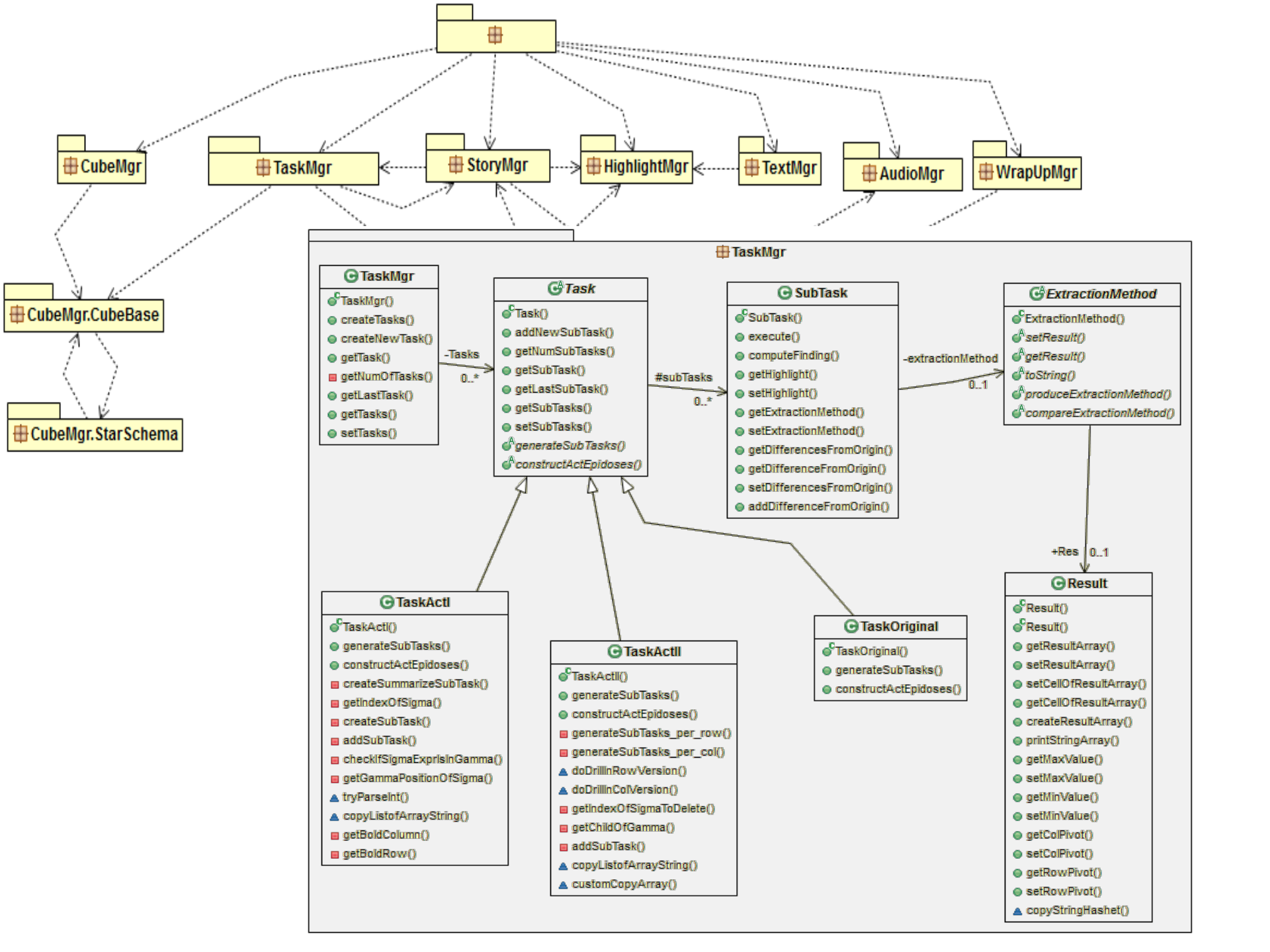
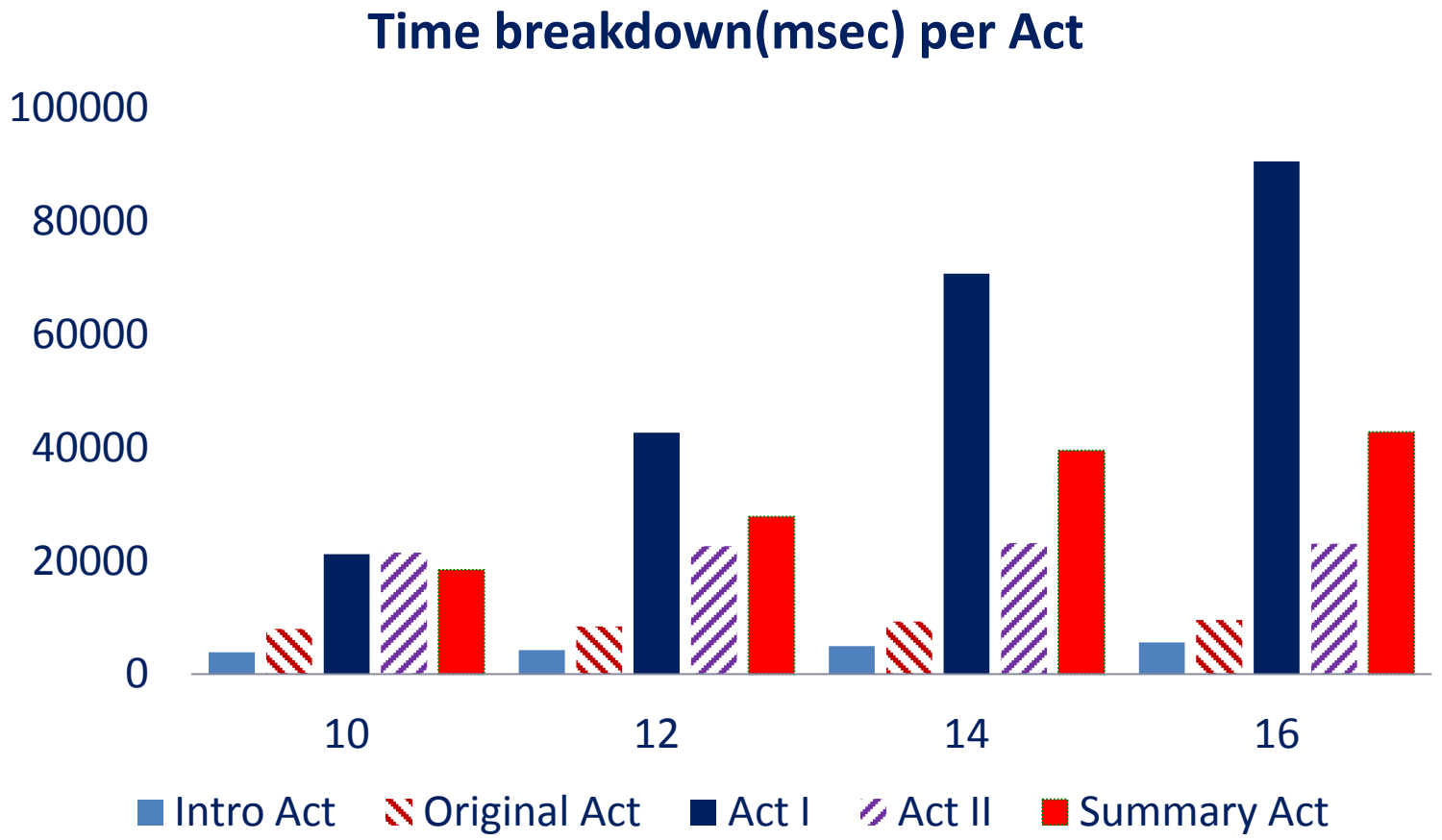
execute()
findDomination()
maxValueInTableColumn()
HighlightMin
HighlightMin()
execute()
isTableMaxValue()
returnConditionForMaxMin()


CubeMgr
TaskMgr
StoryMgr
HighlightMgr
TextMgr
AudioMgr
WrapUpMgr
CubeMgr.CubeBase
CubeMgr.StarSchema
TaskMgr
TaskMgr
TaskMgr()
createTasks()
createNewTask()
getTask()
getNumOfTasks()
getLastTask()
getTasks()
setTasks()
-Tasks
0..*
Task
Task()
addNewSubTask()
getNumSubTasks()
getSubTask()
getLastSubTask()
getSubTasks()
setSubTasks()
generateSubTasks()
constructActEpidoses()
#subTasks
0..*
SubTask
SubTask()
execute()
computeFinding()
getHighlight()
setHighlight()
getExtractionMethod()
setExtractionMethod()
getDifferencesFromOrigin()
getDifferenceFromOrigin()
setDifferencesFromOrigin()
addDifferenceFromOrigin()
-extractionMethod
0..1
ExtractionMethod
ExtractionMethod()
setResult()
getResult()
toString()
produceExtractionMethod()
compareExtractionMethod()
+Res
0..1
Result
Result()
Result()
getResultArray()
setResultArray()
setCellOfResultArray()
getCellOfResultArray()
createResultArray()
printStringArray()
getMaxValue()
setMaxValue()
getMinValue()
setMinValue()
getColPivot()
setColPivot()
getRowPivot()
setRowPivot()
copyStringHashet()
TaskActI
TaskActI()
generateSubTasks()
constructActEpidoses()
createSummarizeSubTask()
getIndexOfSigma()
createSubTask()
addSubTask()
checkIfSigmaExprIsInGamma()
getGammaPositionOfSigma()
tryParseInt()
copyListofArrayString()
getBoldColumn()
getBoldRow()
TaskActII
TaskActII()
generateSubTasks()
constructActEpidoses()
generateSubTasks_per_row()
generateSubTasks_per_col()
doDrillInRowVersion()
doDrillInColVersion()
getIndexOfSigmaToDelete()
getChildOfGamma()
addSubTask()
copyListofArrayString()
customCopyArray()
TaskOriginal
TaskOriginal()
generateSubTasks()
constructActEpidoses()

Experiments

Experiments



Findings concerning ‘fast doers’

- CineCubes did not result in clear time gains!!

- In fact, there was a large number of people who spent more time with CineCubes than with the simple querying system!
  - Why? Observe that the users with time loss were the ones who spent too little time (way less than the rest) for their original report. The small amount of time devoted to the original report, skyrockets the percentage deficit (a user who spends 10 minutes for the original report and 20 minutes for Cinecubes. gets a 100% time penalty).
  - At the same time, this resulted also in an original report of rather poor quality. => significant improvements in the quality of the Cinecubes-based report.

- There are no users with dual loss.
  - Again, the explanation for the time increase is that the users spent extra time to go through the highlights offered by CineCubes.

Findings concerning ‘quality doers’

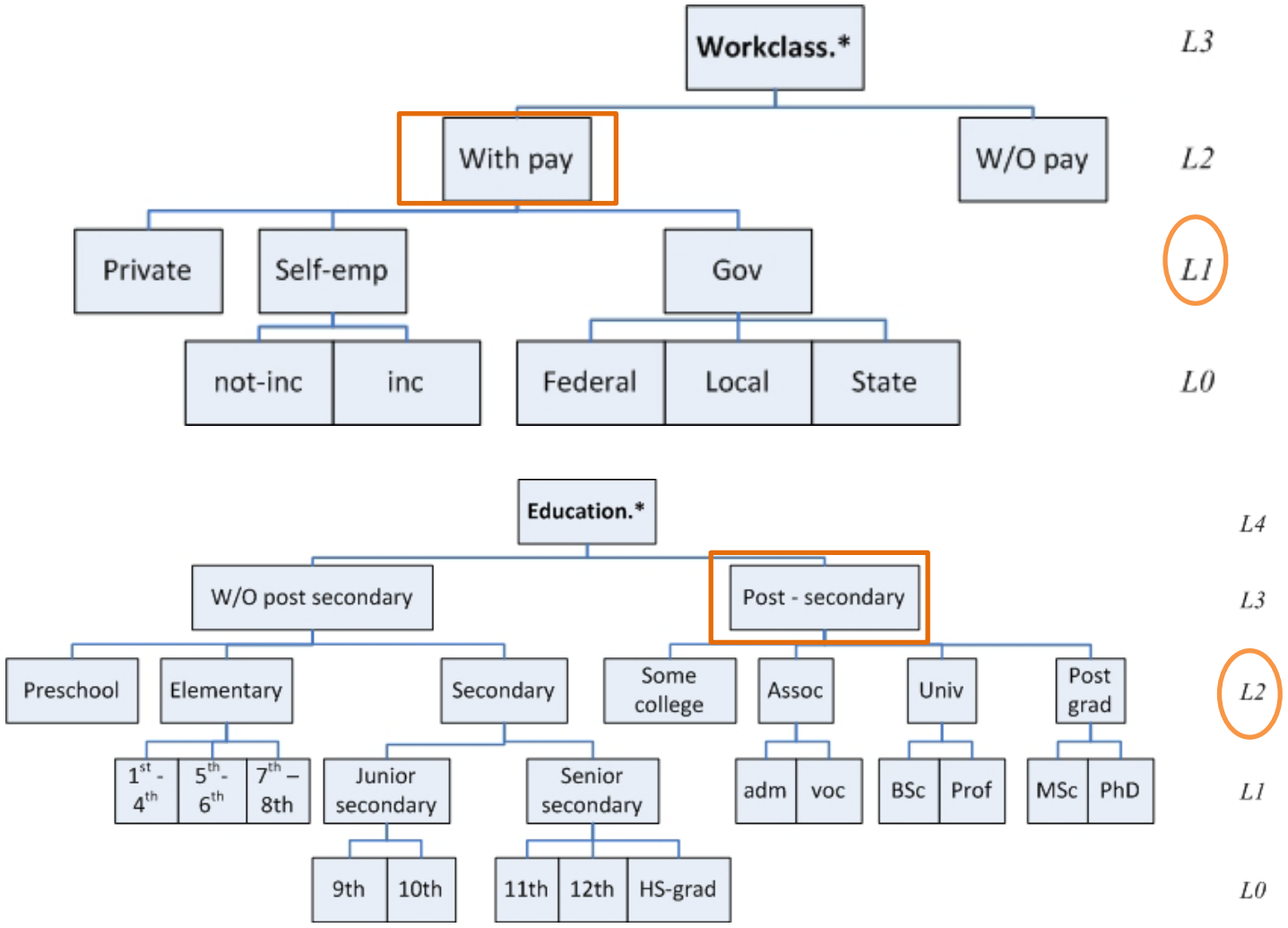
- Users who spent less time with CineCubes than without it are the ones who invested more time working with data than the previous group. In all but one cases, there was **no loss of quality for this group** of users.
- Clearly, for the people who would spend at least 30 minutes for their original report, there is a benefit in time gains.
  - In fact, in all but one cases, the benefit rises with the time spent in the original report
    - the relationship between time and quality improvements for the people with a positive time gain is almost linear, with a Pearson correlation of 0.940;
    - the same applies for the correlation of the time spent without Cinecubes and time improvement with a Pearson correlation of 0.868).
- Interestingly, as these users devoted quite some time working with the data in the first place, they had a quite satisfactory report in the first place (in all but one cases, no less than 3 stars).
  - Therefore, **the improvement of quality is on average half star** (although the distribution of values is clearly biased, as the last column of the data in the table indicates).
  - The speedup rises on average to 37.5 minutes (46%) for these cases.

Various helpful

Data analysis for insight gaining

- How to facilitate insight? Data analysis!
- In a recent SIGMOD keynote speech in 2012, Pat Hanrahan from Stanford University and Tableau Software:
  - " … get the data; deliver them in a clean usable form;
  - contextualize them;
  - extract relationships and patterns hidden within them;
  - generalize for insight;
  - confirm hypotheses and errors;
  - share with others;
  - decide and act…"

Example


Workclass.*
With pay
W/O pay
Private
Self-emp
Gov
not-inc
inc
Federal
Local
State
L3
L2
L1
L0
Education.*
W/O post secondary
Post - secondary
Preschool
Elementary
Secondary
Some college
Assoc
Univ
Post grad
1st - 4th
5th - 6th
7th – 8th
Junior secondary
Senior secondary
adm
voc
BSc
Prof
MSc
PhD
9th
10th
11th
12th
HS-grad
L4
L3
L2
L1
L0

The CineCubes method