

Efficient Structure-aware OLAP Query Processing over Large Property Graphs

by

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I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Property graph model is a widely used model for real life systems of graph structure like social networks, financial transaction networks ect. On-Line Analytical Processing(OLAP) provides an important tool for data analyses by allowing users to perform data aggregation through different combinations of dimentions. For instance, in Q_A

Current graph databases support OLAP queries on property graphs.

However when it comes to large property graphs, current graph databases' efficiency is far from satisfaction. It is unacceptable for users to wait for hours for results of a single query.

We propose a system that greatly improves efficiency of OLAP over large property graphs. Our system is able to smartly select cuboids and substructures based on finished previous and materialize them. Future workload could be processed faster using the materialized cuboids and substructures.

Acknowledgements

I would like to thank Professor Tamer Ozsü and Xiaofei Zhang who made this thesis possible.

Dedication

This is dedicated to my mother Limei Leng whom I love.

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Glossary

computer A programmable machine that receives input data, stores and manipulates the data, and provides formatted output [1](#)

Abbreviations

AAAAZ American Association of Amature Astronomers and Zoologists [1](#)

Nomenclature

dingledorf A person of supposed average intelligence who makes incredibly brainless mis-judgments [1](#)

List of Symbols

- v** Random vector: a location in n-dimensional Cartesian space, where each dimensional component is determined by a random process [1](#)

Chapter 1

Introduction

In the beginning, there was π :

$$e^{\pi i} + 1 = 0 \tag{1.1}$$

A [computer](#) could compute π all day long. In fact, subsets of digits of π 's decimal approximation would make a good source for psuedo-random vectors, [v](#) .

1.1 State of the Art

See equation [1.1](#) on page [1](#).¹

1.2 Some Meaningless Stuff

The credo of the [American Association of Amature Astronomers and Zoologists \(AAAAZ\)](#) was, for several years, several paragraphs of gibberish, until the [dingledorf](#) responsible for the [AAAAZ](#) Web site realized his mistake:

”Velit dolor illum facilisis zzril ipsum, augue odio, accumsan ea augue molestie lobortis zzril laoreet ex ad, adipiscing nulla. Veniam dolore, vel te in dolor te, feugait dolore ex vel erat duis nostrud diam commodo ad eu in consequat esse in ut wisi. Consectetuer

¹A famous equation.

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Chapter 2

Observations

This would be a good place for some figures and tables.

Some notes on figures and photographs...

- A well-prepared PDF should be
 1. Of reasonable size, *i.e.* photos cropped and compressed.
 2. Scalable, to allow enlargement of text and drawings.
- Photos must be bit maps, and so are not scaleable by definition. TIFF and BMP are uncompressed formats, while JPEG is compressed. Most photos can be compressed without losing their illustrative value.
- Drawings that you make should be scalable vector graphics, *not* bit maps. Some scalable vector file formats are: EPS, SVG, PNG, WMF. These can all be converted into PNG or PDF, that pdf_latex recognizes. Your drawing package probably can export to one of these formats directly. Otherwise, a common procedure is to print-to-file through a Postscript printer driver to create a PS file, then convert that to EPS (encapsulated PS, which has a bounding box to describe its exact size rather than a whole page). Programs such as GSView (a Ghostscript GUI) can create both EPS and PDF from PS files. Appendix [A](#) shows how to generate properly sized Matlab plots and save them as PDF.
- It's important to crop your photos and draw your figures to the size that you want to appear in your thesis. Scaling photos with the `includegraphics` command will cause

loss of resolution. And scaling down drawings may cause any text annotations to become too small.

For more information on L^AT_EX see the uWaterloo Skills for the Academic Workplace [course notes](#).¹

The classic book by Leslie Lamport [3], author of L^AT_EX, is worth a look too, and the many available add-on packages are described by Goossens *et al* [1].

¹ Note that while it is possible to include hyperlinks to external documents, it is not wise to do so, since anything you can't control may change over time. It *would* be appropriate and necessary to provide external links to additional resources for a multimedia “enhanced” thesis. But also note that if the **hyperref** package is not included, as for the print-optimized option in this thesis template, any `\href` commands in your logical document are no longer defined. A work-around employed by this thesis template is to define a dummy `\href` command (which does nothing) in the preamble of the document, before the **hyperref** package is included. The dummy definition is then redefined by the **hyperref** package when it is included.

References

- [1] Michel Goossens, Frank Mittelbach, and Alexander Samarin. *The L^AT_EX Companion*. Addison-Wesley, Reading, Massachusetts, 1994.
- [2] Donald Knuth. *The T_EXbook*. Addison-Wesley, Reading, Massachusetts, 1986.
- [3] Leslie Lamport. *L^AT_EX — A Document Preparation System*. Addison-Wesley, Reading, Massachusetts, second edition, 1994.

APPENDICES

Appendix A

Matlab Code for Making a PDF Plot

A.1 Using the GUI

Properties of Matab plots can be adjusted from the plot window via a graphical interface. Under the Desktop menu in the Figure window, select the Property Editor. You may also want to check the Plot Browser and Figure Palette for more tools. To adjust properties of the axes, look under the Edit menu and select Axes Properties.

To set the figure size and to save as PDF or other file formats, click the Export Setup button in the figure Property Editor.

A.2 From the Command Line

All figure properties can also be manipulated from the command line. Here's an example:

```
x=[0:0.1:pi];
hold on % Plot multiple traces on one figure
plot(x,sin(x))
plot(x,cos(x),'--r')
plot(x,tan(x),'.-g')
title('Some Trig Functions Over 0 to \pi') % Note LaTeX markup!
legend('{\it sin}(x)', '{\it cos}(x)', '{\it tan}(x)')
hold off
```

```
set(gca,'Ylim',[-3 3]) % Adjust Y limits of "current axes"  
set(gcf,'Units','inches') % Set figure size units of "current figure"  
set(gcf,'Position',[0,0,6,4]) % Set figure width (6 in.) and height (4 in.)  
cd n:\thesis\plots % Select where to save  
print -dpdf plot.pdf % Save as PDF
```