Big Data and the Multi-model Database

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Introduction, Heli

* Graduated from University of Helsinki (Master of Science, computer science), currently a doctoral student, researcher and lecturer (databases, Big Data, Multi-model Databases, methods and tools for utilizing semi-structured data for decision making) at University of Helsinki
* Worked with Oracle products since 1993, worked for IT since 1990
* Data and Database!
* CEO for Miracle Finland Oy
* Oracle ACE Director
* Ambassador for EOUC (EMEA Oracle Users Group Community)
* Public speaker and an author
* Winner of Devvy for Database Design Category, 2015
* Author of the book Oracle SQL Developer Data Modeler for Database Design Mastery (Oracle Press, 2015), co-author for Real World SQL and PL/SQL: Advice from the Experts (Oracle Press, 2016)

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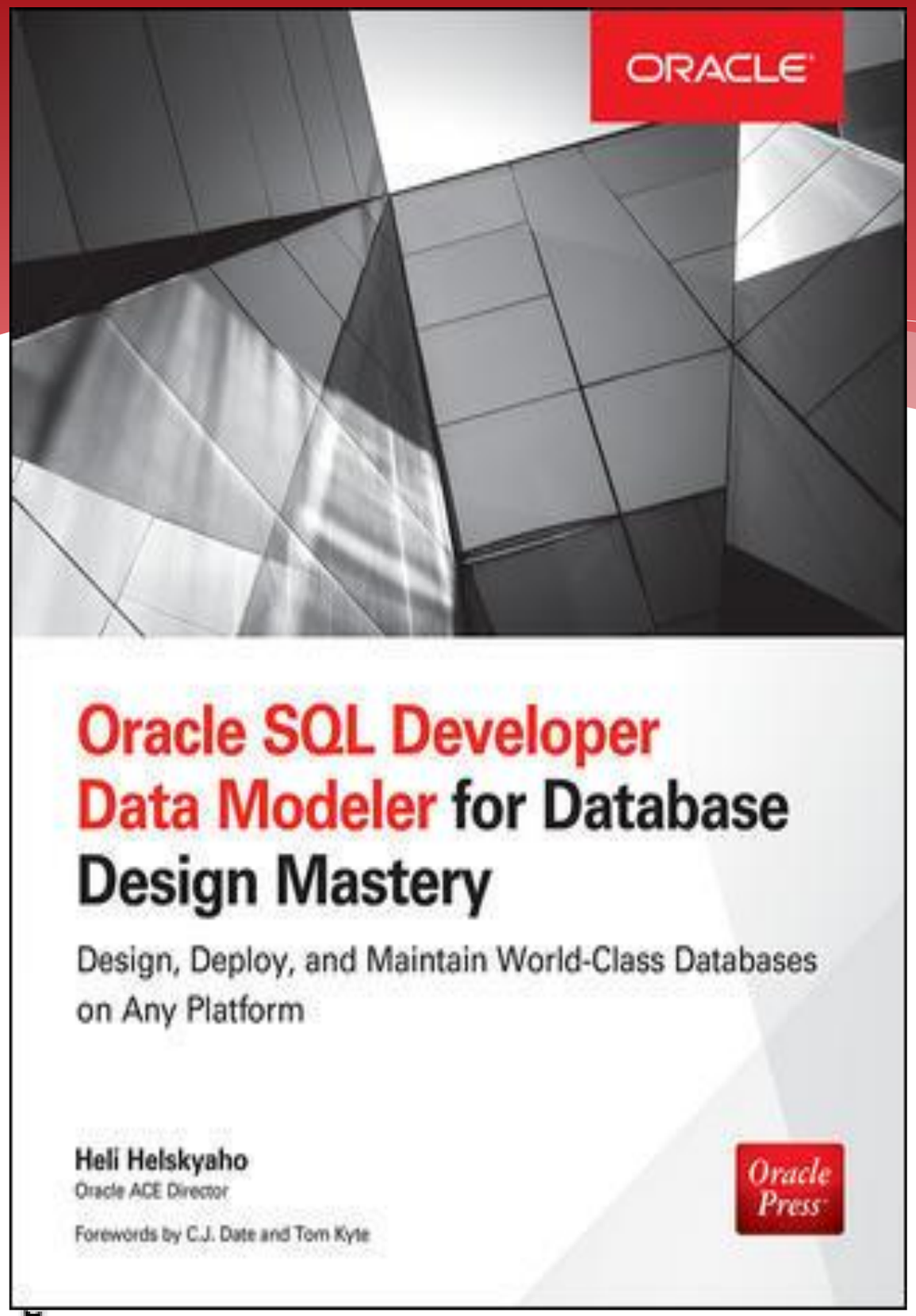

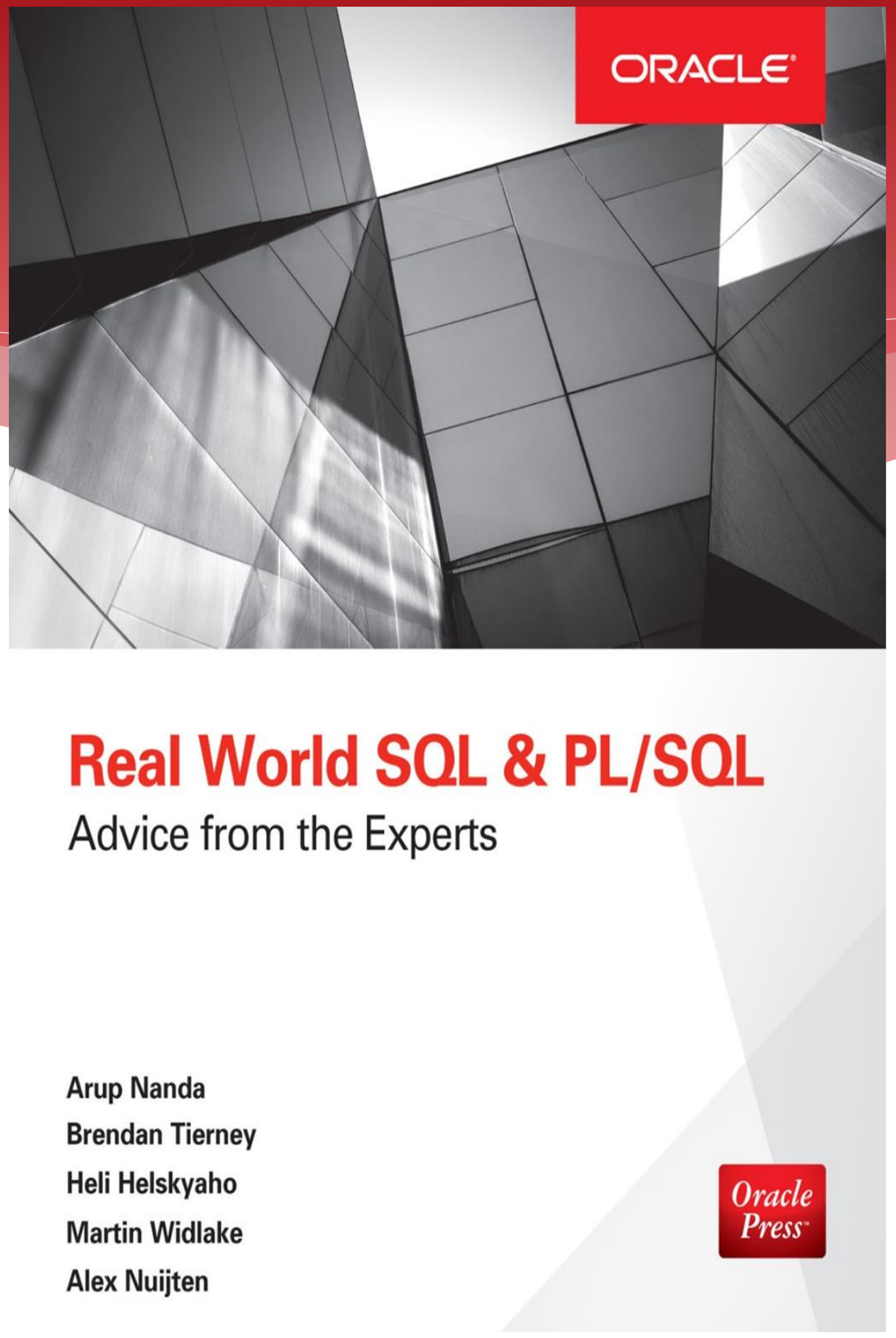

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The history of data models, briefly

* Solutions for *storing and retrieving data*
* The *network* data model, the *hierarchical* data model
  …
* The *relational* data model
* The *relational database* management system (RDBMS)
  * has been de facto as a data model solution for decades
  * based on solid theory
  * standardized environment for storing and retrieving data

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The evolution…

* of software development and programming languages leads to new demands for data models

Objects

* The need to save and retrieve *objects* easily using object-oriented programming languages
  * -> Object databases
  * -> Later these features were added to a RDBMS making it an ORDMS (Object-Relational DataBase Management System)
* Supported in Oracle Database

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XML (Extensible Markup Language)

* To transfer data in a standardized way
* The need to save and retrieve *XML documents* easily
* XML Databases
  * Later these features were added to the RDBMS
* Supported in Oracle Database (XMLType and its methods, SQL functions, indexing, registering XML Schema,…)

Spatial

* The need to save and retrieve *spatial data* easily
* Spatial Databases
  * Later these features were added to the RDBMS
* Supported in Oracle Database

New demand for a Data Model: FSD

* Relational Data: ”schema first, data later”
* Flexible Schema Data (FSD): ”data first, schema later/never”

NoSQL

* An ”umbrella” for different solutions, each for a certain purpose/problem
  * Document Stores
  * Key-value pair stores
  * Column stores
  * Graph stores
* No ACID (Atomicity, Consistency, Isolation, and Durability) but maybe BASE (Basically Available, Soft state, Eventual consistency).
* Scale-up vs scale-out

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Document Stores

* JSON for Javascript programming, lighter version of XML
* The need to save and retrieve *JSON (Javascript Notation) documents* easily
* Supported in Oracle Database (CLOB, NCLOB)

Key-value pair stores

* something between semi-structured and text, key is structured and value is text
* Supported in Oracle Database (+Oracle NoSQL)

Column stores

* Data stored in columns, not rows
* Supported in Oracle Database (in-memory column store)

Graph stores

* About relationships
  * Nodes/vertices, links/edges and properties
    * Each vertix and each edge has a collection of key-value properties
  * A graph can be created from a relational model quite easily

* Supported in Oracle Database

* To me the most interesting of these NoSQL solutions….
* But worth a presentation of its own

NoSQL

* Slowly these features have been added to the RDBMS…

* But can this continue?
  * New feature-> new db-> added to RDBMS

Gartner, Critical Capabilities for Operational Database Management Systems, Dec 9th 2015

Key Findings

* Operational DBMS use cases have *expanded beyond traditional transactions* — still the leading revenue generator — to encompass three additional use cases: distributed variable data; lightweight events and observations; and hybrid transactional/analytical processing (HTAP).
* Relational operational DBMS products and emerging NoSQL and multimodel offerings are entering the market to address some of these new use cases, creating opportunities for best-fit engineering, but threatening established company standards for information management.
* Incumbent vendors are responding by expanding the capabilities of their relational database management systems (RDBMSs) into multimodel territory, but hedging their bets by also adding specialized products to their portfolios, *creating both multimodel and multiproduct choices — and confusion in the minds of buyers*.

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Gartner, Critical Capabilities for Operational Database Management Systems, Dec 9th 2015

Recommendations

* *Identify the use cases you have* under consideration, and assess your current operational DBMS products' fit, costs, deployment options and skills requirements.
* *Evaluate* potential alternative product selections based on best-fit engineering that maps to your use cases — don't pay for features you don't and will not need. Use this Critical Capabilities document alongside its companion Magic Quadrant to identify candidates.
* Issue *RFPs* (using Gartner's RFP Toolkit templates) and conduct proof of concept (*POC*) exercises to confirm and validate candidates.
* *Update your standards, training and support organizations* to manage, qualify and accommodate additional requirements if your technology portfolio is expanding.

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Gartner, Critical Capabilities for Operational Database Management Systems, Dec 9th 2015

Strategic Planning Assumptions

* By 2017, all leading operational DBMSs *will offer multiple data models*, relational and NoSQL, in a single DBMS platform.
* Through 2018, 50% of small operational DBMS vendors will *disappear* due to acquisitions, mergers or business failures.
* By 2017, the *"NoSQL" label will cease* to distinguish DBMSs, reducing its value and resulting in the label falling out of use.

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The Big Data…

* Brings even more than just the need for new data models…

What is Big Data?

* There is *no size* that makes a data to be ”Big Data”, it always depends on the capabilities
* The data is ”***Big***” when traditional processing with traditional tools is not possible due to the amount or the complexity of the data
  * You cannot open an attachement in email
  * You cannot edit a photo
  * etc.

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The three V's

* **Volume**, the size/scale of the data
* **Velocity**, the speed of change, analysis of streaming data
* **Variety**, different formats of data sources, different forms of data; structured, semi-structured, unstructured

The other V's

* **Veracity**, the uncertainty of the data, the data is worthless or harmful if it's not accurate
* **Viability**, validate that hypothesis before taking further action (and, in the process of determining the viability of a variable, we can expand our view to determine other variables)
* **Value**, the potential value
* **Variability,** refers to data whose meaning is constantly changing, in consistency of data; for example words and context
* **Visualization**, a way of presenting the data in a manner that's readable and accessible

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Volume and Velocity

* Are easy to understand and there are plenty of technical solutions to solve the problems but…

Variety leads to…

* -> diversity, complexity, …
* Users can not query all of their data using a *single* high level declarative query language. They have to
  * use different query languages for querying different data
  * implement their own join algorithms to join between relational data and FSD
* Also many specialized systems lack *essential* advanced functionalities, such as ACID and fine grain security, that are the “norm” in RDBMSs

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Data Exploration

* Data exploration is to efficiently extract *knowledge* from data, even though you do *not* know what you are looking for.
* *Exploratory computing*: a conversation between a user and a computer.
  * The system provides active support
  * The exploration process is investigation, exploration-seeking, comparison-making, and learning
  * Wide range of different techniques is needed (the use of statistics, data analysis, query suggestion, advanced visualization tools, etc.)

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Not a new thing…

* J. W. Tukey. Exploratory data analysis. Addison-Wesley, Reading,MA, **1977**:
  * “with *exploratory data analysis* the researcher explores the data in many possible ways, including the use of graphical tools like boxplots or histograms, gaining knowledge from the way data are displayed”

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Old problems and new problems

* More and more data (volume)
* Different data models and formats (variety)
* Loading in progress while data exploration going on (velocity)
* Not all data is reliable (veracity)
* We do not know what we are looking for (value, viability, variability)
* Must support also non-technical users (journalists, investors, politicians,…) (visualization)
* All must be done *efficiently and fast*

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Different Layers

* the user interaction/user interface
* the middleware
* the database layer/engine

Challenges for the User Interaction

* The user interface should help the user to find information she/he was *not* aware of and to find even *more* information based on the information already found.
* The data is in different formats, it is a large amount of different kinds of data and analyzing it takes time.
* The conversation must be *fluently* responsive.
* Not all users are IT professionals
* The query result *visualization* to understand the data and to communicate with the exploration software would be valuable

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User Interaction, Query Visualization

* The role of visualization for data analytics is huge (a picture tells more than 1000 words)
  * visualization tools that assist users in navigating the underlying *data structures*
  * tools that incorporate new types of interactions such as *collaborative annotations* and *searches*
  * Query *result reduction* (aggregation, sampling and/or filtering operations)
  * Query *result* visualization

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User Interaction, User Involvement

* the relevance of an answer for a specific user
  * predict users' *interests* and *anticipations* in order to issue the most relevant answer
* Some possible techniques
  * *Grouping* the users (subgroups)
  * *classify* different notions of relevance
  * devise strategies to *customize* the system response to the user behavior

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Middleware

* Building various optimizations on top of the database layer/engine
  * Can be used to improve the efficiency of the data exploration *without* changing the underlying architecture
* The exploration tasks are computationally heavy and can be speedup in the middleware layer with
  * *Data Prefetching* (and background execution)
  * *Query Approximation*

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Middleware, Data Prefetching

* *caching* data sets which are likely to be used
* the *trade-off* between introducing new results and re-using cached ones
* the main *challenge* is identifying the data set with the highest utility

Middleware, Query Approximation

* The system offers *approximate* answers
* Allows users to get a quick sense of whether a particular query reveals anything interesting about the data
* Need solutions that process queries on *sampled* data sets to provide fast query response times
* the *trade-off* between results accuracy and query performance

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Database Engine/Layer

* A database is all about *saving* and *retrieving* data
* The way the data is *stored* defines the best possible ways of accessing it, the way data is *accessed* defines the best way to store it…
  * We might not know what data we will be loading
  * We do not know what we are looking for

  -> therefore are unable to define the ”best” way of storing
* how can the architecture of database systems be redesigned to aid data exploration tasks?

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Saving

* Efficiently, Reliably
* Understanding the data while saving
  * finding the PK to be able to join to other data
  * Taxonomies to understand that first name = fname?
  * Metadata Management
  * …
* Categorizing
  * Some data is more valuable than other
  * some data is more reliable than other
  * not all the data want to be stored in the same, operational database
  * data classification (reliable/no reliable)

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Saving

* The data need to be *classified* before storing and the qualification might affect where and on which format the data is stored.
  * Maybe transforming?
* Usually the disk space in RDBMS is expensive
  * -> new ways to store the data (Hadoop,…)
* What data to save close to what and why
* todays spam is tomorrows ham (possibility to re-categorize)
* How to handle date datatype?
* …

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Oracle Database

* Quite often the solution for saving a new data model is CLOB, BLOB or external table
* But we need more than that…

Database Engine/Layer, Solutions

1. Adaptive Indexing
2. Adaptive Loading
3. Adaptive Storage
4. Flexible Architecture
5. Architectures tailored for approximation processing

Adaptive Indexing

* creating indexes *incrementally* and *adaptively* during query processing based on the columns, tables and value ranges that queries request
* Indexes are built gradually; as more queries arrive indexes are continuously fine-tuned

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Adaptive Loading

* Not all data is *needed*; users might want to leave some parts of the data unloaded
* Not all data is *available*; users might start querying a database system before all data is loaded

Adaptive Storage

* There is no one perfect solution for storage layout for all the data.
* Adaptive Storage can be used for different needs of storage layouts
* Examples
  * OctopusDB (a central log and Storage Views)
  * H_2O (supports multiple storage layouts and data access patterns, decides during query processing, which design is best for classes of queries)
  * In-memory columnar stores (for example Oracle)
  * real-time materialized views (Oracle 12c rel 2)

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Flexible Architecture

* can tune the architecture to the task at hand
  * by having a declarative interface for the physical data layouts
  * by having a declarative interface for the whole engine
  * using organic databases to continuously match incoming data and queries
    * Start with a schema that is ”good-enough”, schema evolution while loading and querying

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Architectures tailored for approximation processing

* An architecture where storage and access patterns are tailored to efficiently support sampling-based query processing
  * efficient access and updates of sampled data sets
  * In the DB core
  * For example Oracle Database 12c: Adaptive Dynamic Sampling (for the optimizer)
  * DICE (Distributed and Interactive Cube Exploration) faceted exploration of data cubes; combines sampling with *speculative execution* in the same engine
* Design new engines is one of the open challenges.

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Techniques for Large Data Size

* *Summarizing*: fully pre-computing is not possible and not smart
  * The size of data summarized must be large enough to estimate statistical parameters and distributions, but manageable from the computation viewpoint
* *Data mining techniques*
* *Histograms*, presenting a histogram algebra for efficiently executing queries on the histograms instead of on the data, and estimating the quality of the approximate answers
* Effective *pruning techniques*, not all node-paths are interesting from the user viewpoint, and the ones that fail to satisfy this requirement should be discarded as soon as possible.

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Different Data Models

* Two possibilities:
  * Polyglot persistence
  * Multimodel database

Polyglot Persistence

* Different kinds of *data models* are best dealt with *different data stores*
* Data is stored using multiple data storage technologies to support better the usage of the data (applications, components)

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Oracle and Polyglot Persistence

* Even using Oracle technology you can build a polyglot solution:
  * Berkeley DB as a Key-Value store
  * Oracle NoSQL Database as a Key-Value and sharded database
  * OracleTimesTen as an In-Memory Database
  * Essbase for analytic processing
  * …

What's wrong with polyglot

* Different query languages
* Different frontends/user interfaces
* How to join data?
* Is data consistents?
* Is data secured?
* Many different skills needed
* …

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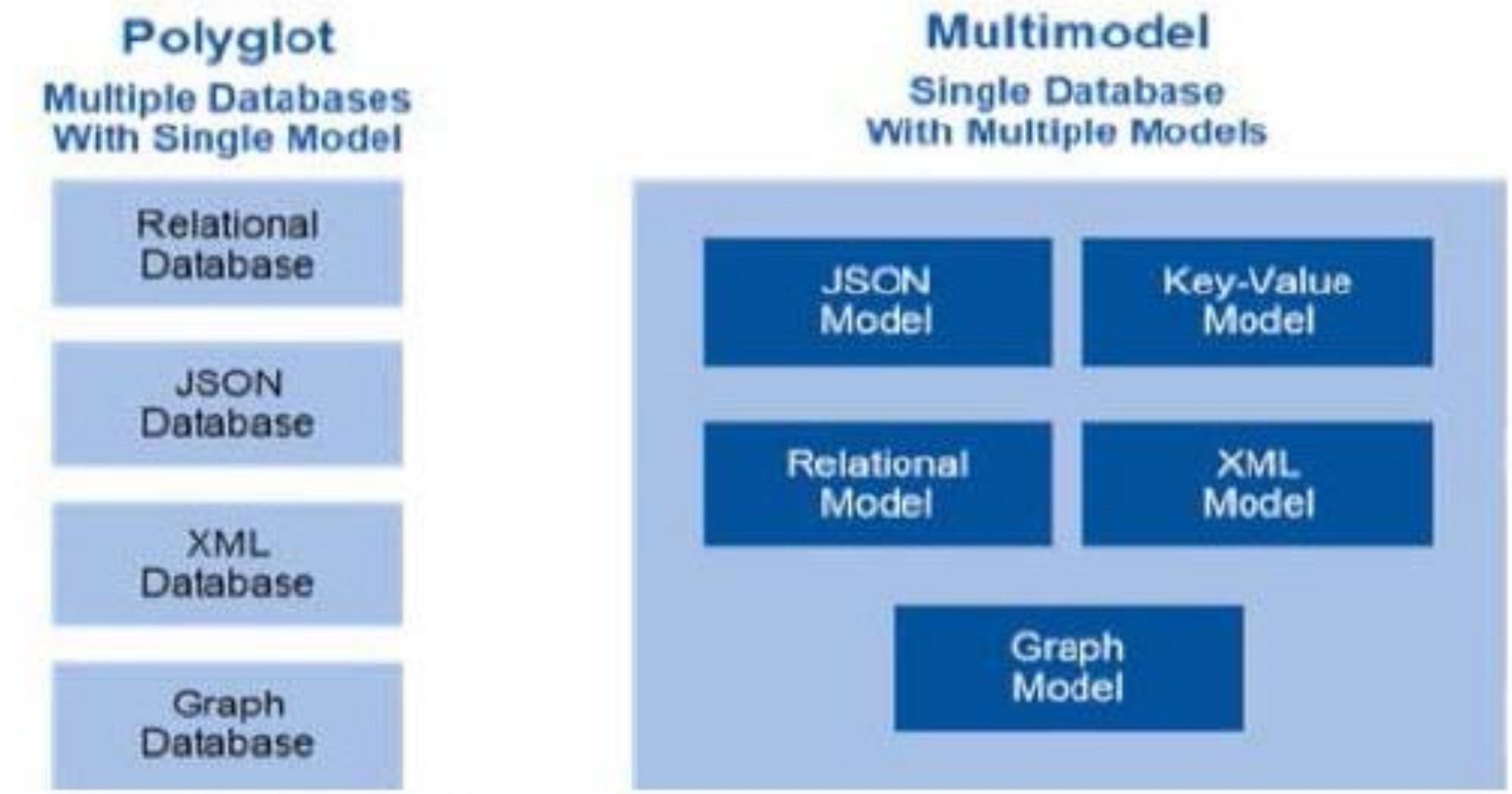
Polyglot vs. Multimodel



JSON = JavaScript Object Notation

Source: The Rise of Polyglot Persistence Demands Your Consideration, Gartner (January, 2015)

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Multi-model database

* A multi-model database is designed to support multiple data models against a single, integrated backend
* One query language
* All data available
* ACID (or any level needed), security, backup/recovery, …
* All the ”good” from relational added with all the ”good” from everywhere else

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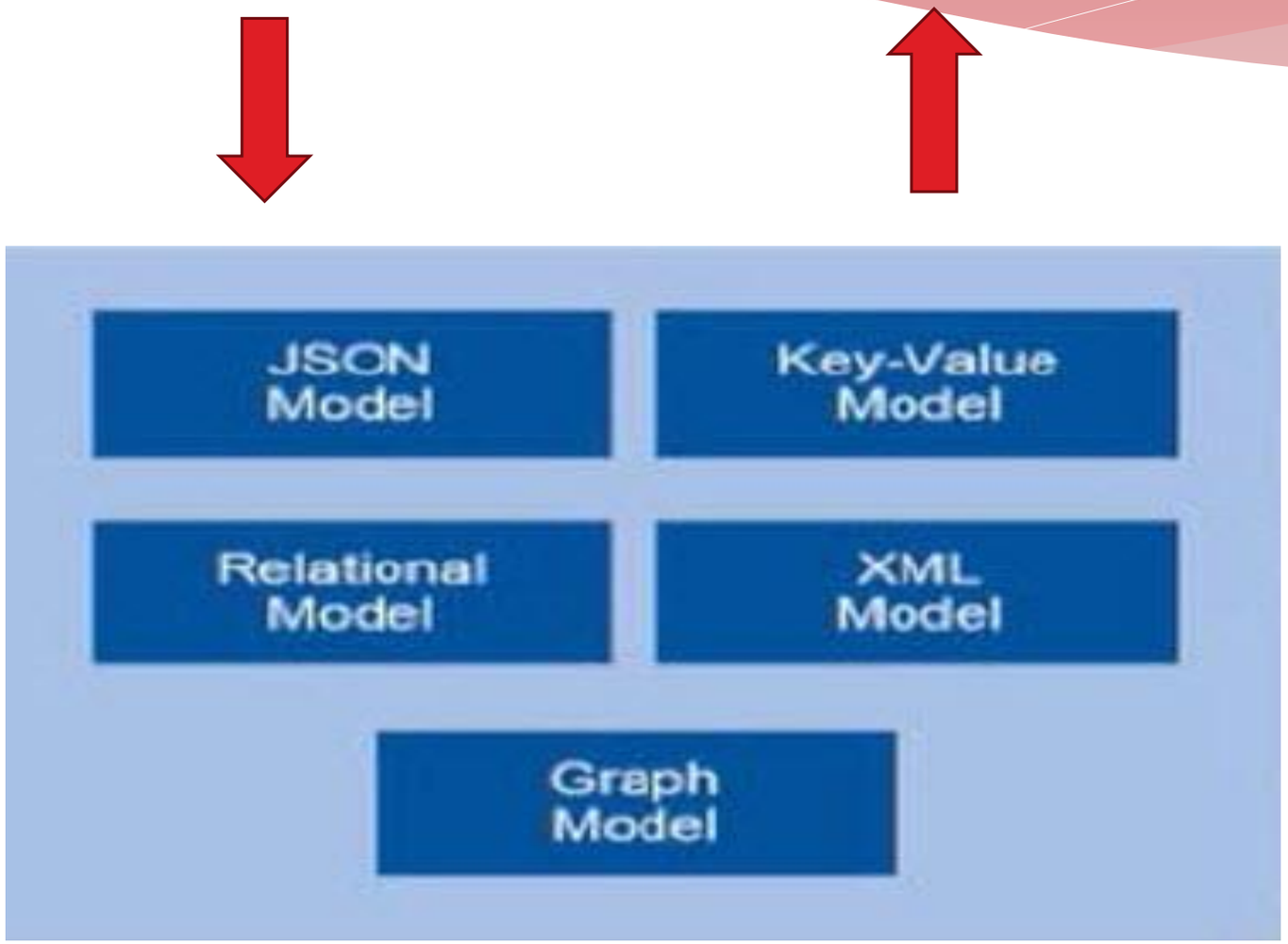
How to save and how to retrive the data?



Interesting solutions in Oracle Database

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JSON DataGuide in Oracle Database 12cR2

* save as it is, use it with SQL
  * Now only JSON, something more in the future?
* “write without schema, read with schema”

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JSON DataGuide in Oracle Database 12cR2

* Enabling FSDM (Flexible Schema Data Management) in a RDBMS
* Storing JSON objects as aggregated, self-described entities without shredding them into relational rows and columns
* Indexing JSON using a schema-agnostic strategy to support ad-hoc queries that search ***both*** schema and values together
* Querying JSON using SQL as the inter-document query language and SQL/JSON path language as the intra-document query language

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Creating a DataGuide

* Two forms of JSON DataGuide
  * Persistent
    * a component of a schema agnostic JSON search index
  * Transient
    * a new SQL aggregate function over any JSON collections that can be computed from SQL declaratively

Creating a DataGuide, Persistent

* DataGuide information is part of the JSON search index infrastructure
  * CREATE SEARCH INDEX FOR JSON
    * Can be created for index only, DataGuide only, both
    * The default is both
    * database privilege CTXAPP needed
* The content of DataGuide is automatically updated whenever the index is synchronized.
* To obtain the DataGuide information stored in a JSON search index use PL/SQL function DBMS_JSON.get_index_dataguide

JSON search index and Data Guide

* When the index is synced, additive *updates* to the document set are automatically reflected in the persisted DataGuide information
* *Deletions* are **not** updated
  * you must create the index again if the data of deletion is needed
* can also include statistics (how frequently each JSON field is used in the document set)
  * Explicitly gathered
  * Not updated automatically

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Creating a DataGuide, Transient

* DataGuide is created by scanning JSON documents (use SQL aggregate function json_dataguide)
* Not updated automatically

Formats of DataGuide

* There are two formats for a DataGuide (both defined as CLOB):
  * Flat
    * to query DataGuide information such as field frequencies and types
  * Hierarchical
    * to create a view, or to add virtual columns, using particular fields that you choose on the basis of DataGuide information
* (DBMS.JSON.FORMAT_FLAT or DBMS.JSON.FORMAT_HIERARCHICAL)

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JSON DataGuide, views

* Relational *views* on top of a set of JSON files for querying the data as it were relational
  * still only saved once and as a JSON document
* You can create multiple views based on the same JSON document set, projecting different fields

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Creating views over JSON data

* Based on a Hierarchical DataGuide
  * The fields projected are those in the *DataGuide*
    * You can edit the DataGuide to include only the fields that you want to project.
    * DBMS_JSON.create_view
* Based on a Path Expression
  * You can use the information in a DataGuide enabled JSON search index to create a database view
  * Columns project JSON fields from your *documents*
  * The fields projected are the scalar fields and the scalar fields in the data targeted by a specified SQL/JSON path expression.

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DataGuide and a Virtual Column

* Based on DataGuide information for a JSON column, you can project scalar fields as virtual columns to the same table that contains this JSON column
  * From
    * hierarchical DataGuide or
    * DataGuide enabled JSON search index
  * DBMS_JSON.add_virtual_columns , DBMS_JSON.drop_virtual_columns
* To improve the performance you can
  * Build an index on it
  * Gather statistics on it for the optimizer
  * Load it into the In-Memory Column Store

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Why DataGuide is interesting?

* It enables FSDM (Flexible Schema Data Management) in a RDBMS
* And as a solution might be used in other cases for different semi-structured data models in the future…

In-Memory

* Save as it is, copy to a faster data model kept in-memory
* Now only columnar store

In-Memory

* Very interesting for retrieving data…
* Saving data as its original data model and showing a copy of it on an in-memory version of another data model when needed
  * Original data as it is and a copy of it created in another data model when needed
    * Fast (relative term ☺)
    * Synchronized automatically
    * No additional storage needed
    * The version of a data model is used that works best for the need
* Maybe other data models could be stored in-memory too? Graph?

Conclusion

* So many data models
  * The network data model
  * The hierarchical data model
  * The relational data model
  * Objects
  * XML
  * Spatial
  * NoSQL models
  * …
* Flexible Schema Data (FSD): ”data first, schema later/never”

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Conclusion

* Several V's related to Big Data…
  * Volume
  * Velocity
  * Variety
  * Veracity
  * Viability
  * Value
  * Variability
  * Visualization
  * …

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Conclusion

* Data exploration is about finding new information and *knowledge* from the data *without* knowing what you are looking for. And it brings a lot of pressure for the performance… in all levels:
  * the user interaction/user interface
  * the middleware
  * the database layer/engine

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Conclusion

* Various data models, solutions
  * Polyglot
  * Multimodel database
* Promising solutions in Oracle Database
  * JSON DataGuide in Oracle Database 12cR2
  * In-Memory

* Plenty of research going on in this area and results needed soon…

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THANK YOU!

QUESTIONS?

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