Why We Learn Database?
Chapter 0

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DB = IT Core Platform in the 21st Century?

The Sumerian Writing System in Mesopotamia:
The first writing of mankind on durable storage media
(i.e., Clay Tablet): to record transactions, not poetry
(See CH 6. Memory Overload @ Homo Sapiens)
A kind of data processing system

- On-Line Transaction Processing (OLTP)
- ERP/CRM/SEM/BSC
- On-Line Analytical Processing(OLAP)/Data Warehouse/Data Mining
- Web Log Analysis (Google, Facebook, Twitter, Naver)
- Mobile/GIS/XML: SQLite inside iPhone and Galaxy
- Scientific database: e.g. Bio-informatics
- MES for many manufacturers, Data Management for Self-Driving Cars(?)
  Cloud computing, **Big Data**, NoSQL, Key-Value Store ..
  - Scale-up vs. scale-out: Oracle vs. NoSQLs
  - Economics
- Data is the new oil in the digital economy
  - ML/AI runs on top of Data.

Why DB Tuning in 21st Century?

- DB performance influences all aspects of your business
  - DB performance management is one of the most important success factors in almost every IT projects
  - "미래 웹경쟁력은 데이터처리능력에"(Scott McNealy, Former Sun CEO)

- DB performance/tuning is not a technical issue, but a business issue!
  - Improve your productivity
  - Increase your revenue/profit
  - Increase your ROI(Return on Investment)

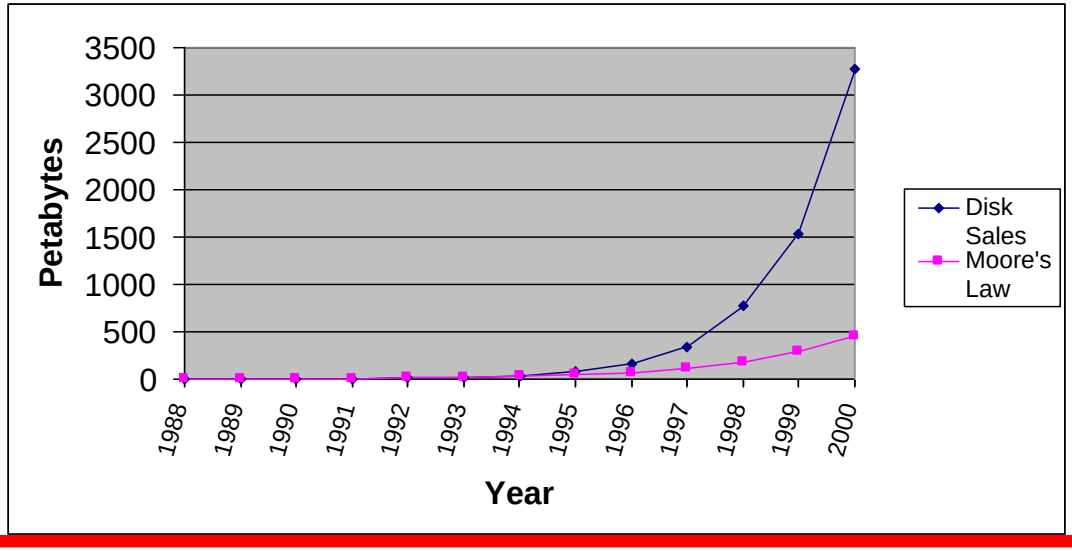
DB Performance Impact: Real Story

- After tuning SQLs in a shopping mall application program
  - 30% (5M$) increase in Sales

- When an index is dropped in an Internet auction site
  - Reduction in benefit: 200K$/day

Databases: Bigger, Complex, Faster

- More data – doubles every 9 month
- More users - from CEO to sales representatives
- More complex query - e.g. OLAP/data mining query
- Faster responses
  - e.g. web response time impacts revenue!
  - e.g. real time personalization



- Data growth vs. computer speedup

* Moore's Law -- # of transistors/chip doubles every 18 months (1965)

Real Customer Story

	2000	2001	2002	2003
Raw Data (excl. indexes, etc.)	~1 TB	2.3 TB	9 TB	13 TB
Users	330	512	800	800
Queries / Day	630	1,000	4,300	6,000
Percent Queries < 5 mins	63%	77%	80%	80%
Direct SQL Access	No	Yes	Yes	Yes
User Schedule/Publish Reports	No	Yes	Yes	Yes

In just three years:

- 13x growth in raw data
- 10x growth in number of queries
- ~3x growth in number of users
- additional lines of business supported
- increasing numbers of partners supported

...with better performance!

Big, Big, Big Data: How much data?

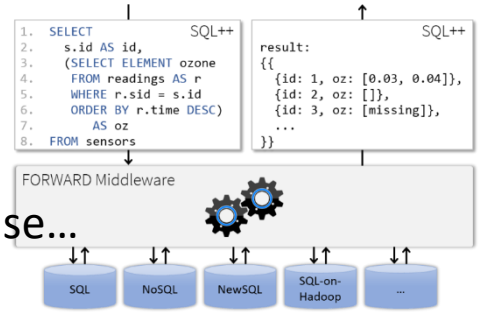
- Google processes 20 PB a day (2008)
- Wayback Machine has 3 PB + 100 TB/month (3/2009)
- eBay has 6.5 PB of user data + 50 TB/day (5/2009)
- Facebook has 36 PB of user data + 80-90 TB/day (6/2010)
- CERN's LHC: 15 PB a year (any day now)
- LSST: 6-10 PB a year (~2015)

- 2020s: the Zetabyte era
  - The Yottabyte era is near

From http://www.umiacs.umd.edu/~jimmylin/

Database in Big Data Era

- Is the DB field dead? (5 Years ago)
- We are witnessing the BIG DATA era
  - A paradigm shift in 21st century
  - Google's MapReduce: big data processing on cluster computing
  - SQL-on-{Hadoop, NoSQL}
    - ✓ Hive, Pig, Impala, Cloudera, Tajo, ..
    - ✓ LSMtree/LevelDB/RocksDB, MongoDB, Cassandra, Couchbase…
    - ✓ MarReduce → Hadoop -> Apache **Spark** → Spark SQL



- SQL: Esperanto in big data era?

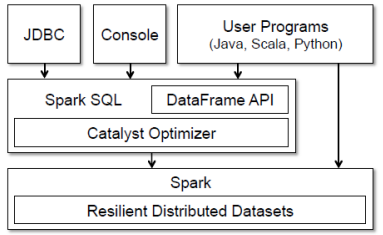


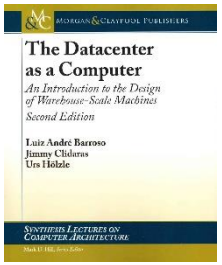
Figure 1: Interfaces to Spark SQL, and interaction with Spark.

RDBMS vs. NoSQL

- ... doesn't expect big companies like JPMorgan to ditch Oracle as that would be an expensive endeavor. He said regarding Oracle that "while revenue is not growing, it is not declining," which can be associated with the hundreds of thousands of current Oracle companies that aren't likely to leave Oracle any time soon. Those companies **have Oracle databases firmly embedded into their current architecture and applications**. But companies like Couchbase can pick off new applications even at these big companies. (http://fortune.com/2015/07/13/oracle-cfo-board-couchbase/)
  - Oracle annual maintenance fee
  - Can organizations which have been already locked in Oracle leave the company?

Database Systems for the Cloud

- "The Datacenter as a Computer"
- Cloud-first world



- Database systems for the cloud (source: cs245.Sanford.edu)
  - Amazon S3 & Dynamo: object stores (@SOSP 2007)
  - Amazon Aurora: transactional DBMS (@SIGMOD 2017/2018)
  - Google BigQuery: analytical DBMS (@VLDB 2020)
  - Delta Lake: transactional ACID over object stores (@VLDB 2020)

+ MS Azure Hyperscale, Alibaba LegoDB, Naver Cloud MySQL/Postgres …

1.2 DBMS History & Big Guys

- See the supplementary notes at the end of this file

A History of DBMS Research

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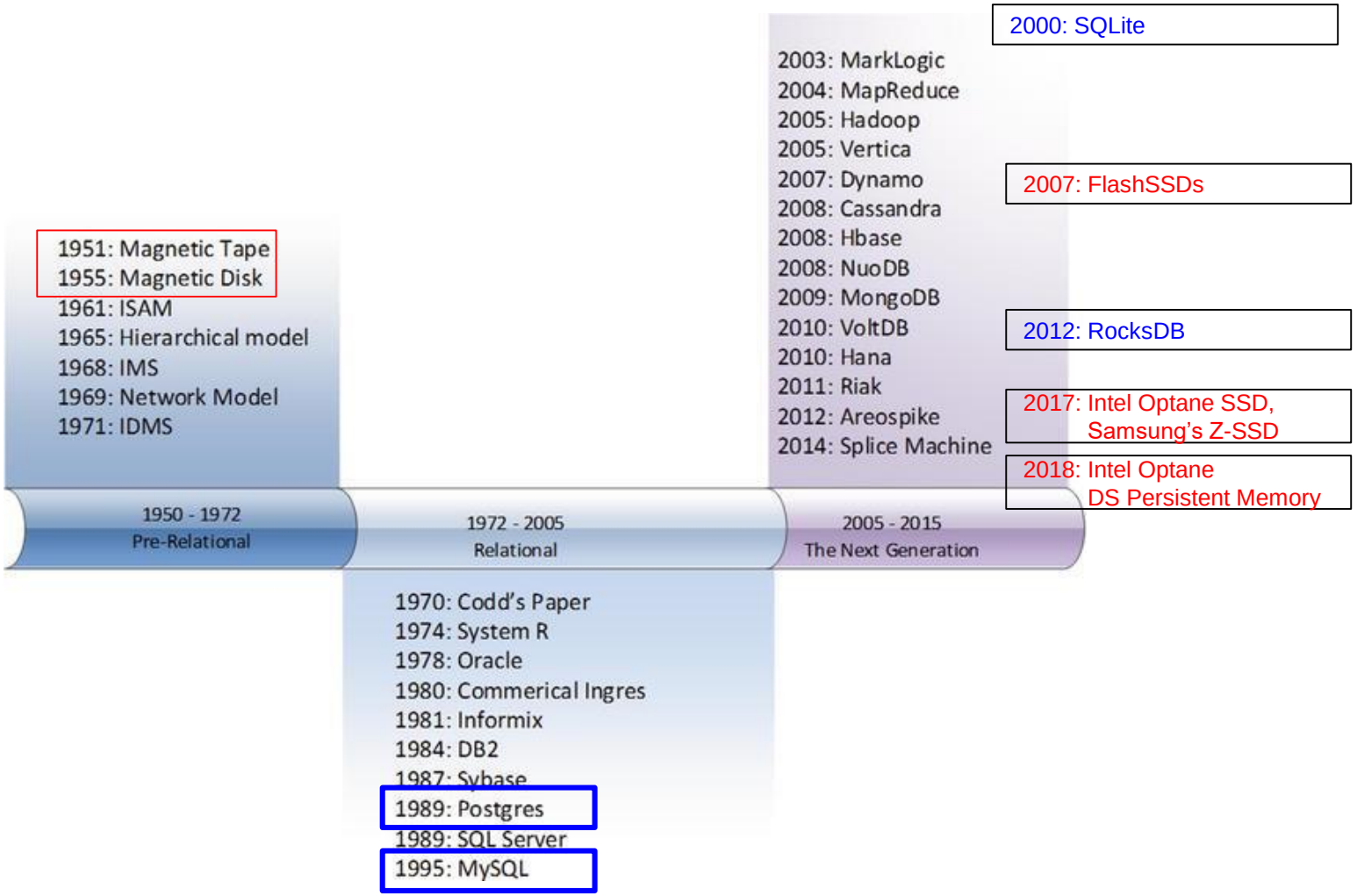
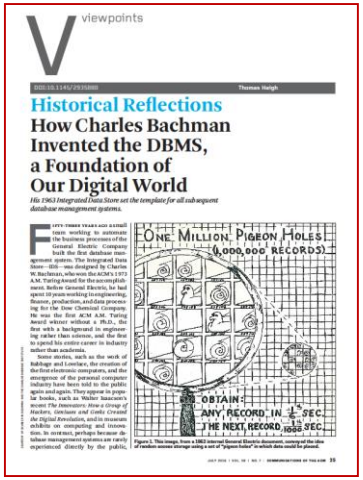
Database History



Source: Next Generation Databases - NoSQL, NewSQL, and Big Data, Guy Harrison, 2015, Apress

Database Architecture and C. W. Bachman

- Invented “database concept” and “layered architecture” (IDS @ General Electronics, 1964)
- The 1st ACM Turing Award Recipient in database field
  - “The programmer as navigator”@Turing Lecture
  - Bachman diagram
  - http://www.cbi.umn.edu/collections/inv/cbi00125.html
  - http://www.free-definition.com/Charles-Bachman.html
- Hierarchical data model (IBM IMS)
- Codasyl’s Network data model


viewpoints

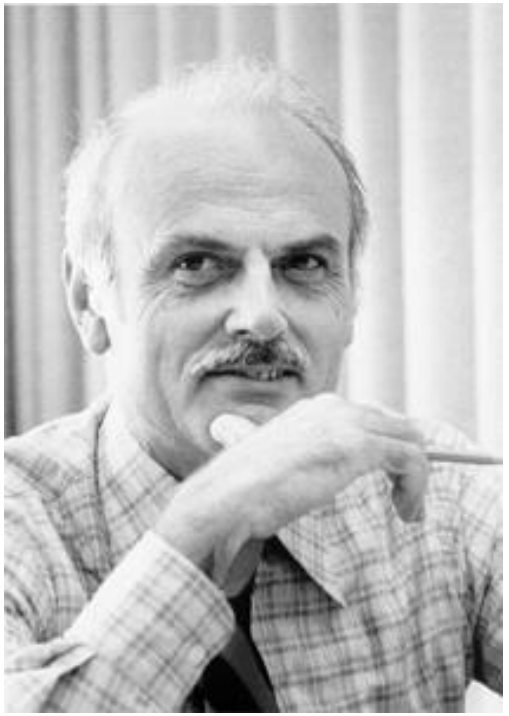
Historical Reflections

How Charles Bachman Invented the DBMS, a Foundation of Our Digital World

His 1963 Integrated Data Store set the template for all subsequent database management systems.

Relational Model (ch 3, 4) and E. F. Codd

- A Relational Model of Data for Large Shared Data Banks
  Communications of the ACM, Vol 13, No 6, June 1970
  - First draft in 1969 IBM Research Report
  - "The relational model provides a basis for a high level data language which will yield maximal independence between programs on the one hand and machine representation on the other. (*Turing Award lecture, 1981*; **2nd** in DB community)
- Codd's Great Insights to turn database technology from ad hoc to science (source: The database relational model (by C. J. Date)
  1. DB as a set of relations(or tables)
  2. Relation as a set of propositions
  3. Formal logic (relational algebra and calculus) as data access apparatus
- A tribute by C. J. Date



ER Model (ch 2) and P. Chen

- The Entity-Relationship Model - Toward a Unified View of Data. ACM Trans. Database Syst. 1(1): 9-36 (1976)

- There was a joke that he, together with Elvis, came from the Mars.

System R

- IBM Almaden (San Jose) Research Center
- 1995 SQL Reunion: People, Projects, and Politics

Ingres & Postgres

- Berkeley
- Ingres → **Postgres** → Informix Illustra
- Vertica, VoltDB
- ACM Turing Award Winner (2015, 4th in DB community)

Mike Stonebraker:
Berkeley → MIT

1990 - Present

- OO-DBMS, OR-DBMS, XML Database
- OLAP / Data Warehouse
- MySQL @ 1995 (https://en.wikipedia.org/wiki/MySQL)
- Stream database
- Big Data / NoSQL
  - LSM-tree @ 1996 (https://www.cs.umb.edu/~poneil/lsmtree.pdf)
  - RocksDB is eating the database world
- Cloud-Native DBs:
  - Cloudify Open Source DB (MySQL,Postgres)
  - E.g. Amazon Aurora, Alibaba LegoDB etc.

Wisconsin
(www-db.cs.wisc.edu)

Now at MIT

Now at Google

Now at Google

Stanford
(www-db.stanford.edu)

https://cs.stanford.edu/people/matei/

Berkeley

- (Stonebraker) & J. Hellerstein

http://db.cs.berkeley.edu/~jmh/

MIT, Yale, CMU etc

- MIT: Stonebraker, Sam Madden, Tim Kraska
- Yale: Silberschatz, Daniel Abadi

- CMU: Andy Pavlo
- European Universities
  - EPFL: Anastasia Ailamaki

  - Universitat Jena: Viktor Leis

Oracle

System R: Relational Approach to Database Management

M. M. ASTRAHAN, M. W. BLASGEN, D. D. CHAMBERLIN,
K. P. ESWARAN, J. N. GRAY, P. P. GRIFFITHS,
W. F. KING, R. A. LORIE, P. R. McJONES, J. W. MEHL,
G. R. PUTZOLU, I. L. TRAIGER, B. W. WADE, AND V. WATSON

IBM Research Laboratory

System R is a database management system which provides a high level relational data interface. The system provides a high level of data independence by insulating the end user as much as possible from underlying storage structures. The system permits definition of a variety of relational views on common underlying data. Data control features are provided, including authorization, integrity assertions, triggered transactions, a logging and recovery subsystem, and facilities for maintaining data consistency in a shared-update environment.

The paper contains a description of the overall architecture and design of the system. At the present time the system is being implemented and the design evaluated. We emphasize that System R is a vehicle for research in database architecture, and is not planned as a product.

Key Words and Phrases: database, relational model, nonprocedural language, authorization, locking, recovery, data structures, index structures
CR categories: 3.74, 4.22, 4.33, 4.35

1. INTRODUCTION

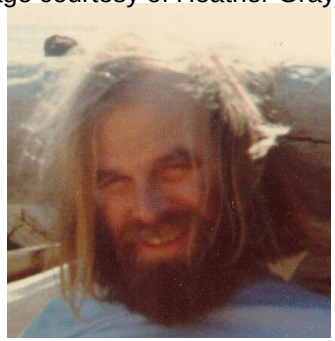
The relational model of data was introduced by Codd [7] in 1970 as an approach toward providing solutions to various problems in database management. In particular, Codd addressed the problems of providing a data model or view which is divorced from various implementation considerations (the data independence problem) and also the problem of providing the database user with a very high level, nonprocedural data sublanguage for accessing data.

To a large extent, the acceptance and value of the relational approach hinges on the demonstration that a system can be built which can be used in a real environment to solve real problems and has performance at least comparable to today's existing systems. The purpose of this paper is to describe the overall architecture and design aspects of an experimental prototype database management system called System R, which is currently being implemented and evaluated at the IBM San Jose Research Laboratory. At the time of this writing, the design has been

Author's address: IBM Research Laboratory, San Jose, CA 95193.
ACM Transactions on Database Systems, Vol. 1, No. 2, June 1976, Pages 97-137.

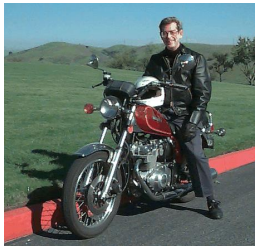
IBM

Jim Gray (3rd Turing award winner in DB)
with his colleagues
Gianfranco Putzulo and Irving Traiger
in the late '70' / early '80s
when they did groundbreaking work
on concurrency control for databases
(image courtesy of Heather Gray)



C. Mohan

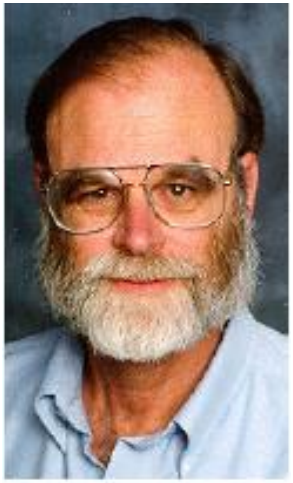
P. Selinger

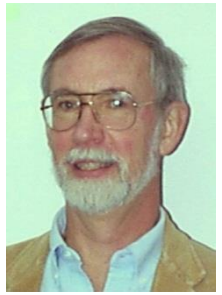


Don Chamberlin

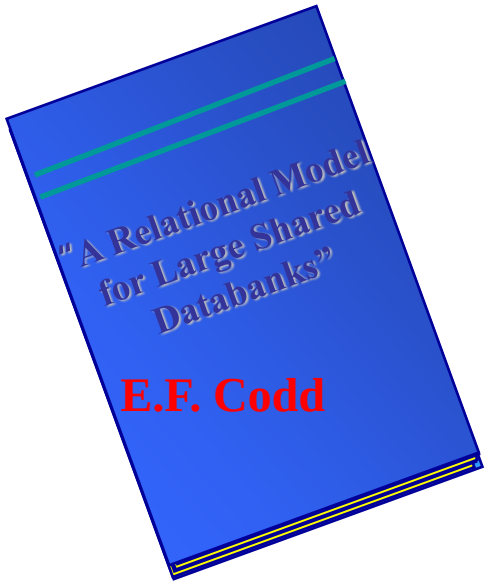
Rakesh Agrawal

MS



Beginning / Experimental / Commercial



IBM System R

INGRES

ORACLE

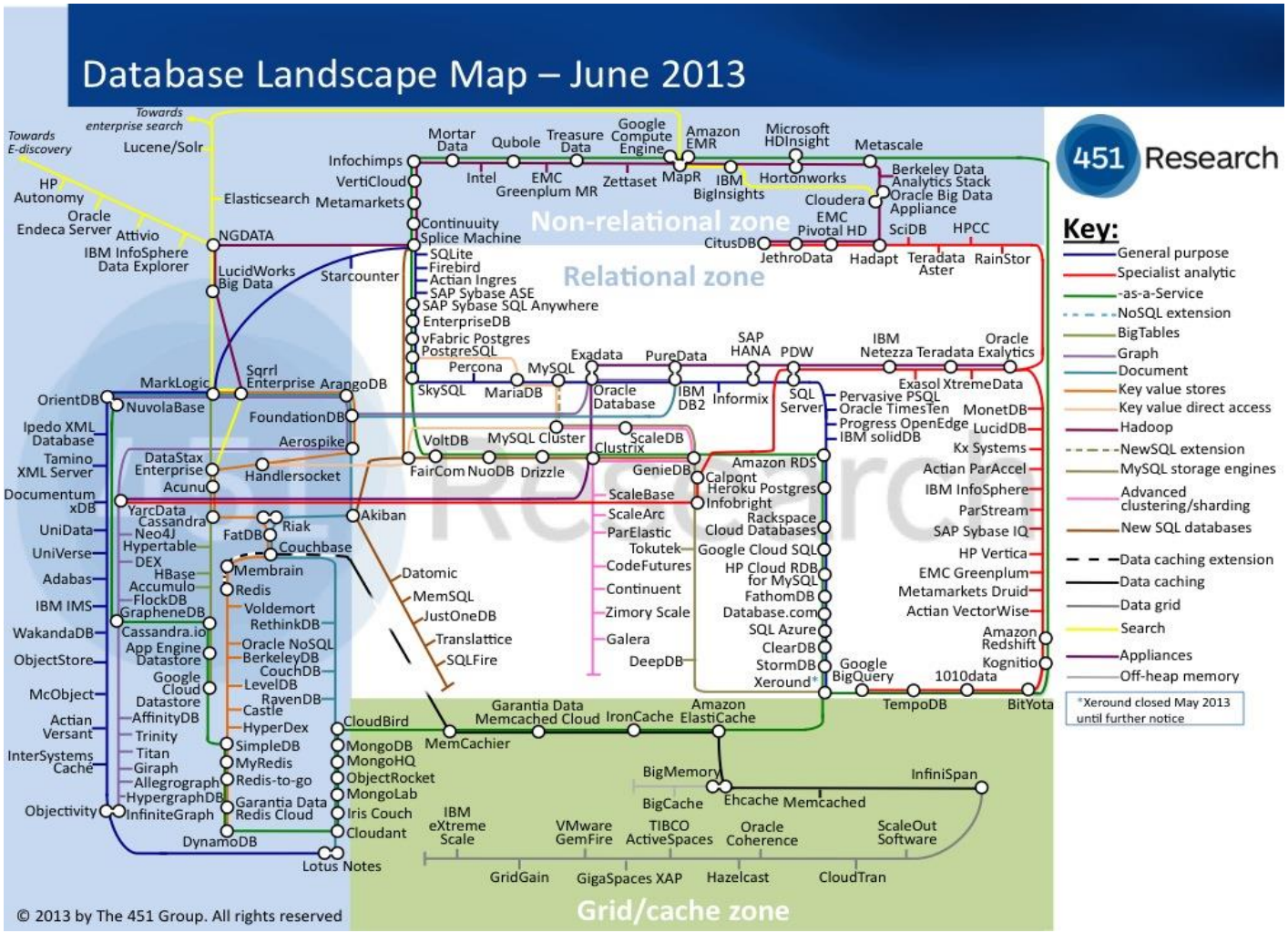
INGRES

IBM SQL/DS

- Data Independence
- Set-oriented, Declarative Language

1970 1979 1982

Database Landscape



Source: http://blogs.the451group.com/information_management/2013/06/10/updated-database-landscape-map-june-2013/

Another example: http://www.hpi.uni-potsdam.de/fileadmin/hpi/FG_Naumann/projekte/RDBMSGenealogy/RDBMS_Genealogy_V1.pdf

Won Kim:

SQL Rewrite(ch14), Orion(OO-DBMS), UniSQL (OR-DBMS, now CubridDB)

Database Related Companies in Korea

- Oracle, MS, IBM Korea
- Altibase, T-max Tibero, Cubrid (formerly UniSQL)
- EncoreConsulting, Ex-Em
- Cloud Service Providers: Naver Cloud, NHN Cloud, Kakao, KT Cloud ..

VLDB Lab.

Very Large Data Bases

http://vldb.skku.ac.kr

- Research Direction
  - Vision: “Flash is disk, disk is tape, and tape is dead.”(by Jim Gray)
  - Strategy: “Do only what only you can do.”(by E. W. Dijkstra)
  - Current Research: “Database systems on flash memory”

    + CloudDB
  - Goal: SQL-on-Flash pioneer

    + Leverage Flash in Cost-Effective and High-Performant CloudDB
- Recent Achievements
  - FAST: One of the most efficient FTL mechanisms (ACM Transactions on Embedded Computing Systems, 2007)
  - IPL: An innovative database storage scheme for flash memory (ACM SIGMOD 2007)
  - And more ….

Database as Bedrock of Modern Civilization

- "In his 1986 book, *The Control Revolution: Technological and Economic Origins of the Information Society*, James Beniger showed how the introduction of railroads and the telegraph in the 19th century enabled the growing complexity of the economy. JoAnne Yates described the intimate connection between information technology and economic complexity in her 1989 book, *Control through Communication: The Rise of System in American Management*. Modern technology has enhanced this trend to the point that Bruce Lindsay, a well-known IBM database researcher, recently quipped that "relational databases form the bedrock of Western civilization." Indeed, if a massive electromagnetic pulse wiped out our computing infrastructure, our society would face a catastrophic collapse." - source: The Financial Meltdown and Computing, Moshe Y. Vardi, Communications of the ACM, Vol. 52 No. 9, Sep., 2009

- A Former Oracle Korea –CEO - "What if technical support for Oracle database maintenance in Korea is no longer provided?"