01-intro

- 为什么要上这门课
  - DBMS developers are in demand and there are many challenging unsolved problems in data management and processing.

    确实dbms很火爆，现在国内形势下很多公司都要自己更生。Dell等外企估计会受到影响

    他提到DBMS developers do not have to work in the context of DBMS。灵活性也挺高
  - If you are good enough to write code for a DBMS, then you can write code on almost anything else.
- HISTORY OF DATABASES
  - Stonebraker argues that a lot of the issues relevant a long time ago are still relevant today
    - 引用
      - M. Stonebraker and J. Hellerstein. What goes around comes around. Readings in Database Systems, 4, 2005
  - The "SQL vs. NoSQL" debate of the 2010s is reminiscent of the "Relational vs. CODASYL" debate from the 1970s

    数据系统语言会议（Conference on Data Systems Languages, CODASYL）是1959年,美国国防部召开的一个有政府机关、企业、计算机厂商参加的会议
    - 引用
      - A. S. Michaels, B. Mittman, and C. R. Carlson. A comparison of the relational and codasyl approaches to data-base management. ACM Comput. Surv., 8(1), Mar. 1976. URL http://doi.acm.org/10.1145/356662.356668.
- Course Outline
  - Course Objectives
    - Learn about modern practices in database internals and systems programming
  - Course Topics

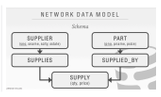
    单节点，in-memory数据库。不讲分布式

    会涉及state-of-the-art话题
    - Concurrency Control
    - Concurrency Control Indexing
    - Storage Models, Compression
    - Parallel Join Algorithms
    - Networking Protocols
    - Logging & Recovery Methods
    - Query Optimization, Execution, Compilation
    - New Hardware (NVM, FPGA, GPU)
- 1960s
  - IDS

    Integrated Data Store

    Oral-History:Charles Bachman. http://ethw.org/Oral-History:Charles Bachman, April 2011.

    T. Haigh. How charles bachman invented the dbms, a foundation of our digital world. Commun. ACM, 59(7):25-30, June 2016. URL http://doi.acm.org/10.1145/2935880.
    - First DBMS
    - Developed internally at GE in the early 1960s by Charles Bachman
    - GE sold their computing division to Honeywell in 1969.
    - Based on the Network Data Model that supported Tuple-at-a-time query execution
      - 引用
        - C. W. Bachman. On a generalized language for file organization and manipulation. Commun. ACM, 9 (3):225-226, 1966. URL http://doi.acm.org/10.1145/365230.365272
  - CODASYL

    R. W. Taylor and R. L. Frank. Codasyl data-base management systems. ACM Comput. Surv., 8(1): 67-103, Mar. 1976. URL http://doi.acm.org/10.1145/356662.356666.
    - Proponents of COBOL and the network data model people got together and proposed a standard for how programs will access a database
    - The ***Network Data Model*** made it difficult to write complex queries due to the sets that main- tained relationships. It also made these early systems more susceptible to corruption
      - 

        Complex Queries：集合互相连接，需要不同的for loops。例如对每一个supplier，遍历所有的supplies，看supply什么。需要在COBOL上编写

        Easily Corrupted: 如果Supplies集合丢失，那么整个数据库就corrupt掉了
  - IMS

    IBM Information Management System (IMS)

    B. Klein, R. A. Long, K. R. Blackman, D. L. Goff, S. P. Nathan, M. M. Lanyi, M. M. Wilson, J. Butterweck, and S. L. Sherrill. An Introduction to IMS: Your Complete Guide to IBM Information Man- agement System. IBM Press, 2nd edition, 2012.
    - Early database system developed to keep track of purchase orders for Apollo moon mission.
    - Based on the ***Hierarchical Data Model*** that organized collections of data with parent/child relationships.
      -

        1. 重复的数据：两个供应商用同样的零件

        2. 没有独立性：define data structure ahead of time，如果需要改变数据结构需要dump+重新加载
    - Programmer-defined physical storage format (e.g., hash table vs. tree) and tuple-at-a-time query execution.

      一个table，需要定义加载table的时候要用hashtable还是tree-based index。

      基于选择的数据结构，数据库系统expose不同的编程接口

      Tree：Range queries

      Hashtable：执行Range queries需要dump+load back in as a tree
- 1970s
  - Relational Model

    Relational Model

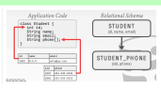
    E. F. Codd. A relational model of data for large shared data banks. Commun. ACM, 13(6):377-387, June 1970. URL http://doi.acm.org/10.1145/362384.362685.

    Ted Codd发现Schema改变以后codebase也要改变

    提出了用Database abstraction解决这个问题
    - Codd created the relational model abstraction to avoid this maintenance based on three key ideas
      - 1. Store database in simple data structures
      - 2. Access data through high-level language
      - 3. Physical storage left up to implementation
    -

      多对多，中间表
  - Early implementations of relational DBMSs:
    - IBM Research: System R
    - U.C. Berkeley (Mike Stonebraker): INGRES
    - Relational Software, Inc. (Larry Ellison): Oracle
- 1980s
  - The relational model wins the database marketplace over CODASYL
    - IBM DB2 ORACLE Informix TANDEM SYBASE TERADATA INGRES InterBase
    - IBM released their first relational DBMS (***DB2***) in 1983.
    - System R's "SEQUEL" declarative query language becomes the standard (later renamed to "SQL").
    - Many new enterprise DBMSs are invented (***Informix, Sybase, TeraData***) but Oracle wins market-ketplace.
    - Stonebraker leaves ***INGRES***, returns to Berkeley and starts the ***Postgres*** project.
  - Object-Oriented Databases

    S. B. Zdonik and D. Maier, editors. Readings in Object-oriented Database Systems. Morgan Kaufmann Publishers Inc., 1990. ISBN 0-55860-000-0.
    - Argued that how people wrote code and how data is stored in a database is different
    - Avoid "relational object impedance mismatch" by tightly coupling objects and database.
    - Few of these original DBMSs from the 1980s still exist today. These systems performed poorly when executing complex queries. There was also no standard API or programming language.

      但是很多以其他形式存在，比如JSON和XML
    - Object-Oriented Model
      - 

        需要Join
      -

        coupled

        不要store things are normalized relation, but denormalize collections/objects

        问题：

        1. **复杂的查询**
        2. 没有标准API — early DMBS没有标准的编程语言，都是不同系统用不同的
- 1990s
  - No major advancements in database systems or application workloads.
  - Microsoft forks ***Sybase*** and creates ***SQL Server*** for Windows NT.
  - ***MySQL*** is written as a replacement for ***mSQL***.
  - Illustra (the commercial version of ***Postgres***) gets bought by ***Informix***. Graduate students at Berkeley take the original academic ***Postgres*** code and adds support for SQL.
  - ***SQLite*** started in early 2000.
- 2000s

  交易多了

  很多大厂开始写中间件来scale out单节点DMBS，或者自己写DBMS（Google: Bigtable）
  - ***Data Warehouses***

    One typical class of workloads

    OLAP DBMSs

    一般闭源

    NETEZZA PARACCEL monetDB Greenplum DATAllegro VERTICA
    - Distributed / Shared-Nothing
    - Relational / SQL
    - Usually closed-source
    - Significant performance benefits from using ***Decomposition Storage Model*** (i.e., columnar storage).
  - ***NoSQL Systems***

    Inject quickly，无延迟

    redis mongoDB Couchbase neo4j riak RAVENDB

    R. Cattell. Scalable sql and nosql data stores. SIGMOD Rec., 39:12-27, 2011. URL http://doi.acm.org/10.1145/1978915.1978919.
    - Focus on high-availability and high-scalability
    - Schema-less
    - Non-relational data models
    - No ACID transactions

      ACID：**Atomicity, Consistency, Isolation, Durability**
    - Custom APIs instead of SQL
    - Usually open-source
- 2010s
  - NewSQL Systems

    M. Aslett. How will the database incumbents respond to NoSQL and NewSQL? The 451 Group, April 2011. URL http://www.the451group.com/report view/report view.php?entity id=66963.

    A. Pavlo and M. Aslett. What's really new with newsql? SIGMOD Rec., 45(2):45-55, Sept. 2016. URL http://doi.acm.org/10.1145/3003665.3003674.

    S-Store Clustrix ScaleBase VoltDB MEMSQL HyPer
    - Strive to provide same scalability and performance for OLTP workloads as NoSQL DBMSs without giving up ACID.
    - Relational / SQL
    - Distributed
    - sually closed-source
  - Hybrid Transactional-Analytical Processing (HTAP)

    M. Pezzini, D. Feinberg, N. Rayner, and R. Edjlali. Hybrid Transaction/Analytical Processing Will Foster Opportunities for Dramatic Business Innovation. https://www.gartner.com/doc/2657815/ 2014.

    MEMSQL HyPer SNAPPY LucidDB splice Peloton
    - Execute fast OLTP like a NewSQL system while also executing complex OLAP queries like a data warehouse system.
    - Distributed / Shared-Nothing
    - Relational/SQL
    - Mixed open/closed-source
  - Cloud-based Database Systems

    snowflake FAUNA
    - First database-as-a-service (DBaaS) offerings were "containerized" versions of existing DBMSs (e.g., Amazon RDS).
    - There are new DBMSs that are designed from scratch explicitly for running in a cloud environment.
  - Specialized Database Systems
    - Shared Disk (HDFS, EBS)
    - Embedded
    - Time-Series
    - Multi model
    - Blockchain

01-intro-note