CMPT 843 Paper Presentation
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A History and Evaluation of System R

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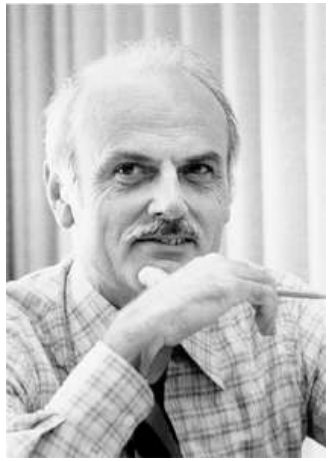
Let’s time travel to 1970

- What was the state of Database Systems then ?

The leading commercial database of it’s time was a hierarchical one : IBM’s IMS

Data was linked in a tree-like structure. It’s still a success today	✓
Laborious to maintain relationships between data	✗
Locations of data had to be known	✗
Physical Links had to be maintained and making changes to the database were daunting	✗
Queries were crude	✗



Relational Model by Dr. Ted Codd

Relational Model

Activity Code	Activity Name
23	Patching
24	Overlay
25	Crack Sealing

Key = 24

Activity Code	Date	Route No.
24	01/12/01	I-95
24	02/08/01	I-66

Date	Activity Code	Route No.
01/12/01	24	I-95
01/15/01	23	I-495
02/08/01	24	I-66

- Codd's approach was rather different, favoring a declarative model.
- This meant the programmer "declared" relationships and the computer would be expected to implement them in bits and bytes.

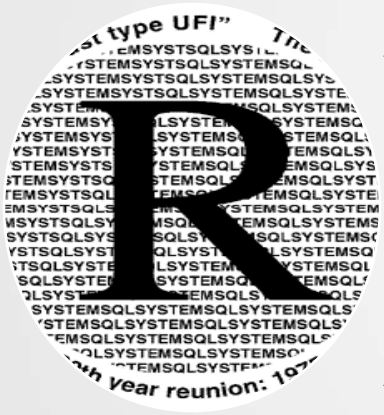
How IBM cracked System R

In 1973 Big Blue decided to do something about this, and consolidated its database research in San Jose, California.

IBM gave its research staff beautiful buildings in serene locations - San Jose

Codd had joined IBM's research labs in 1970, and the move brought him into contact to some clever engineers.

About this Research Paper



What

- Prototype System R designed by IBM (Started from 1974 – 1979)
- Experimental DB system constructed for transition of Relational Model from theory to reality

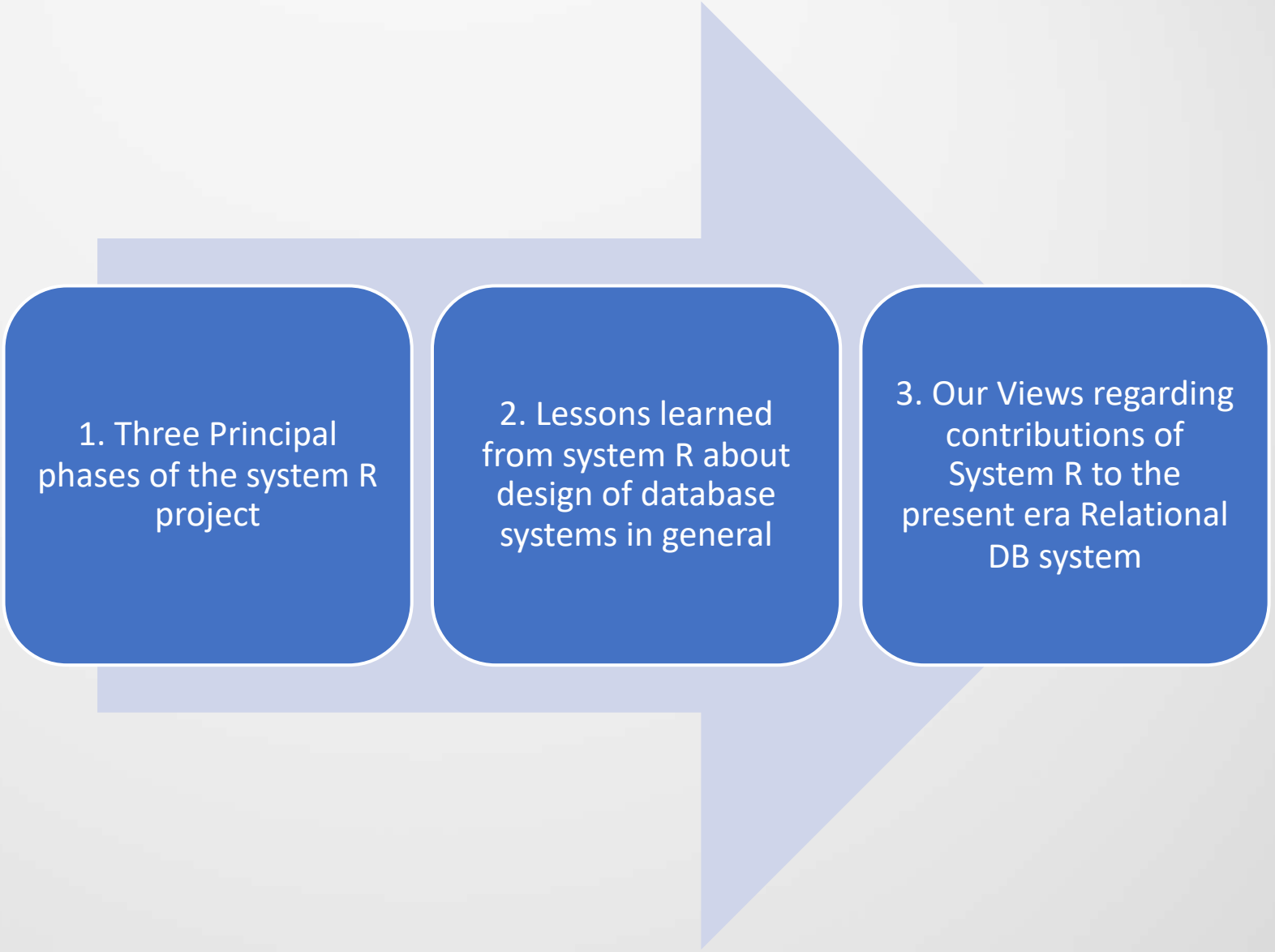
Where & When

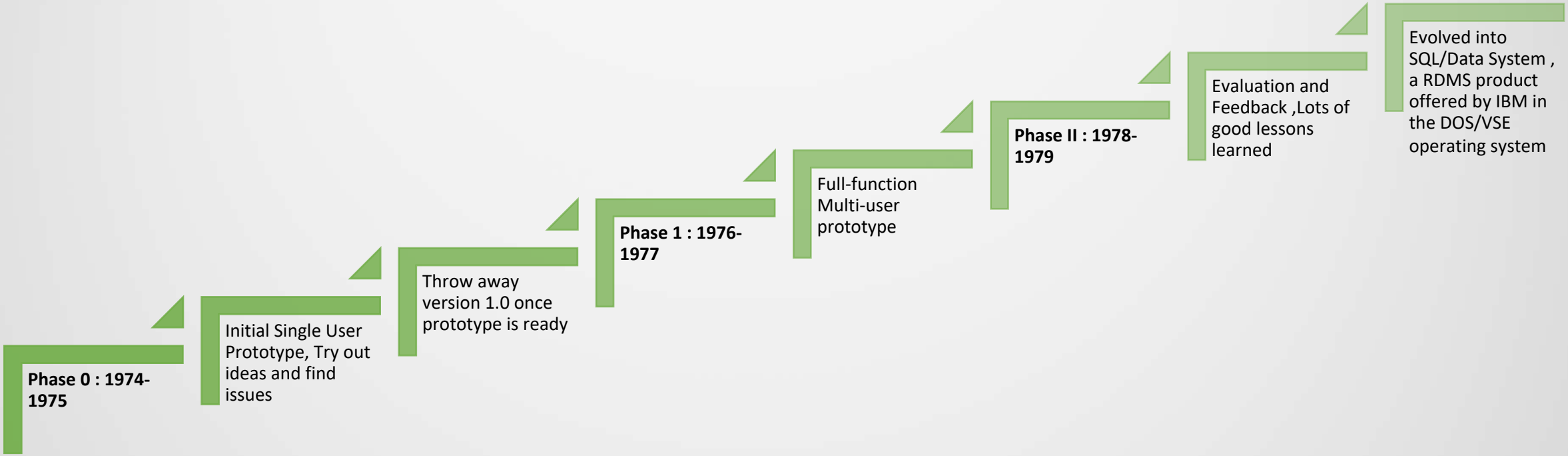
- IBM's Research Lab at San Jose , California
- Communications of the ACM (Association for Computing Machinery) , October 1981
- Lots of PhD researchers out of which 16 researchers published this paper

Why

- Data Independence
- User Productivity

Key points


1. Three Principal phases of the system R project
2. Lessons learned from system R about design of database systems in general
3. Our Views regarding contributions of System R to the present era Relational DB system



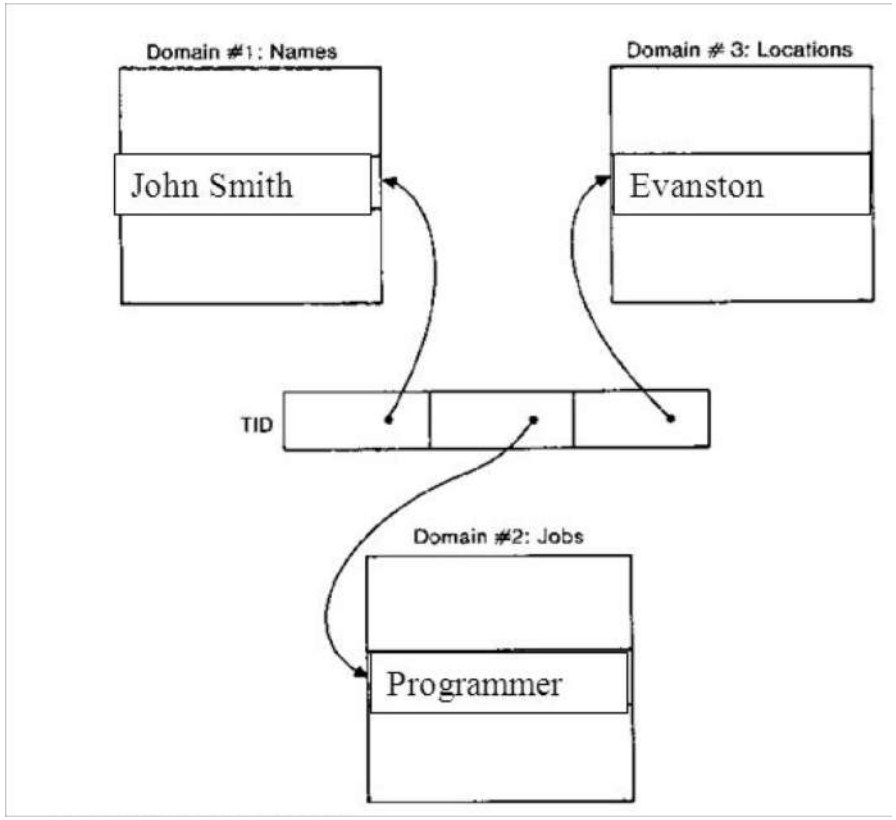
SYSTEM R CASE STUDY IN A NUTSHELL

System Modules Identified

- Log/Recovery System
- Lock Manager
- Data Storage
- View Management
- Access Methods
- Query Optimizer

➢ Basic Design Decisions

- System Catalog
- XRM as Access method



➢ Challenges

- Optimizer Algorithm

➢ Result

- Usability of SQL

➢ Lessons Learned

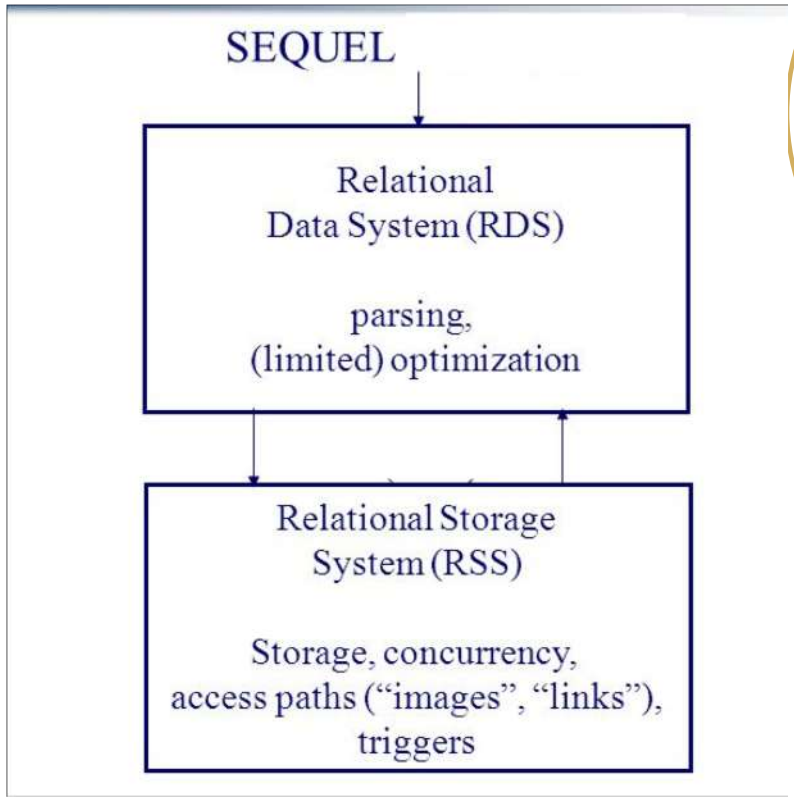
- Optimizer Cost calculation
- Need of ”Join” in SQL
- How can the complexity of Optimizer by reduced

Phase 0

End of Phase 0 (1974 – 1975)

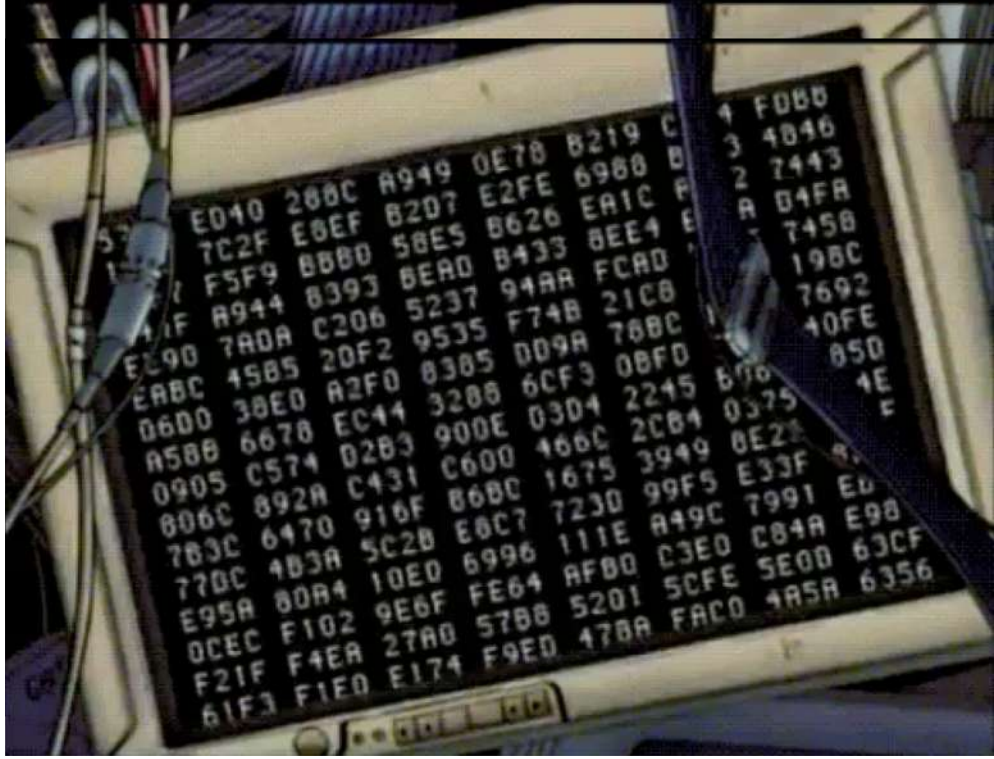
Functionality	Phase 0
Access Method	XRM
Concurrency	Single User
Lock Method	N/A
Recovery	N/A
Query Complexity	Supports Subquery but not “Join”
Interactive level	Standalone Query Interface
Security	N/A
Compilation Approach	N/A

- **Architecture** : RSS, RDS
- Designed to support multiple concurrent users
- Locking sub-system
- Authorization sub-system
- Recovery Sub-system
- Compilation Approach

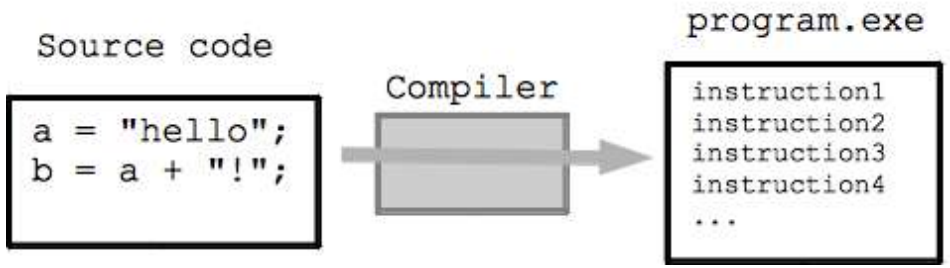


Phase 1

➢ Compilation Approach



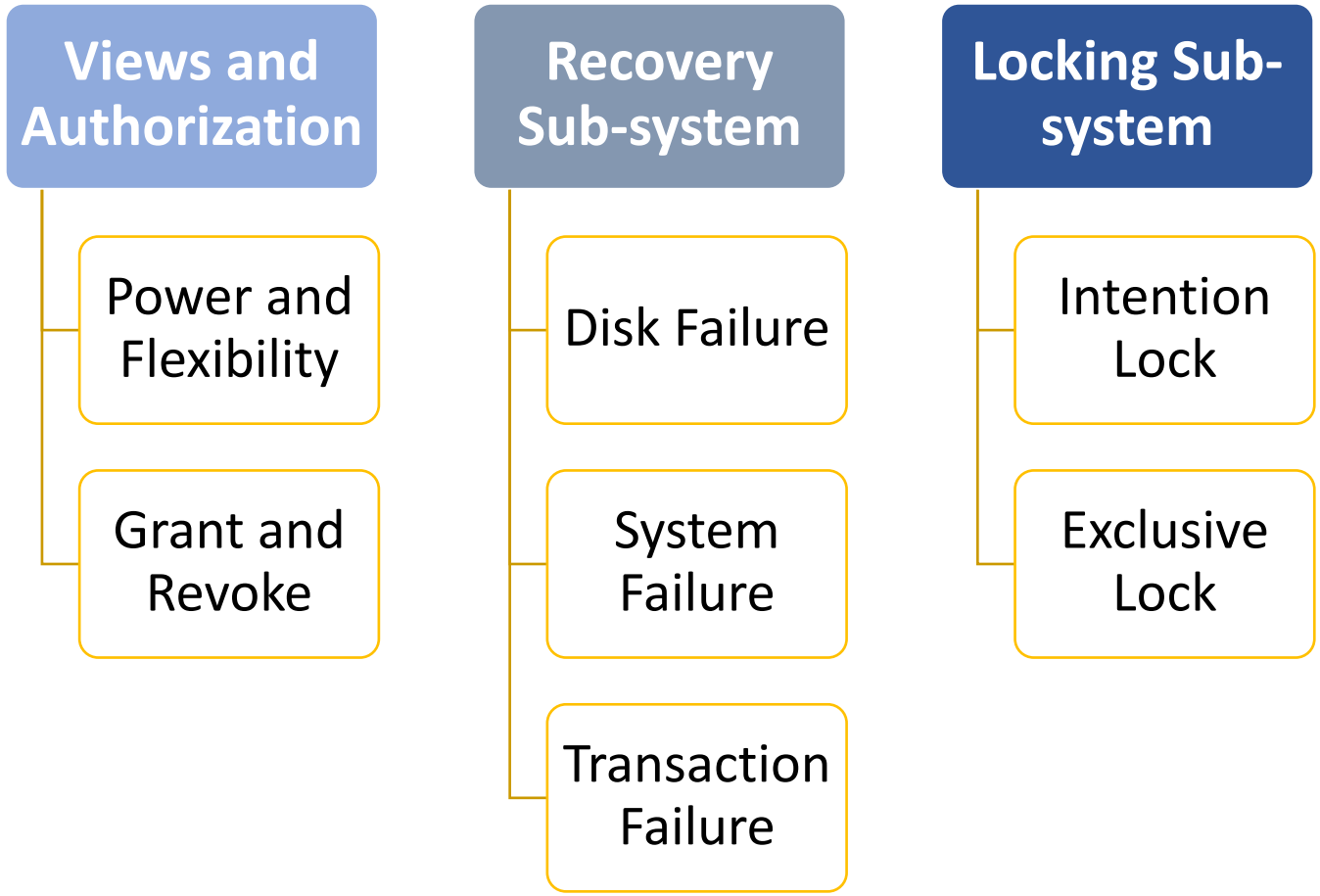
- Inspired by R. Lorie's observation in early 1976



- SQL statements are compiled into efficient machine language routines and further packed into access module
- When program goes into execution, access module is invoked to the RSS

➢ RSS Access Paths

- RSS provides indexes.
- Indexes are maintained automatically in the event of updates to the database.
- RSS access path includes three different kind of scans :
  - ❑ Index Scans
  - ❑ Relation Scans
  - ❑ Link Scans
- ”Search Arguments”



Important Sub-systems which were introduced

End of Phase 1 (1976 – 1977)

Functionality	Phase 0	Phase 1
Access Method	XRM	RSS,RDS
Concurrency	Single User	Multiple User
Lock Method	N/A	Intention Locks, Exclusive Locks
Recovery	N/A	w.r.t. Disk, System, Transaction failures
Query Complexity	Supports Subquery but not “Join”	Joins were introduced
Host- Capability	Standalone Query Interface	Supported PL/I , Cobol, Standalone QI (Called UFI)
Security	N/A	Views were introduced
Compilation Approach	N/A	Yes

Evaluation Period (1978-1981)

- Evaluation phase consisted of two parts :

1. Experiments performed on the system in the Lab
2. Use of R system on IBM's several internal sites and at 3 selected customer sites.

- General User Comments :

1. Easy installation
2. High level user language
3. Ability to reconfigure the DB
4. SQL was identified to be simple, user-friendly and data independent.
5. SQL code was platform independent (w.r.t. adhoc query , application programs)
6. Compilation approach was applauded for it's approach to make the compilation easy

Suggestions

- Need of functions like “Exists” , “Like” operators. **Which we currently hold now in RDBMS systems**
- Need for “Outer Joins”. **Exist with us now**
- Authorization could be augmented to the group instead of users. **Access is now provided to groups**
- Creating new table out of existing table. **We have functionality of %InsertSelect now**
- Shadow pages concept introduced in Recovery sub-systems could have an alternative of simply keeping the logs of all the updates.

**These suggestions with SQL language were later presented as a paper published in 1980 as a user-experience with SQL data sublanguage*

Conclusions

- Cost was defined as weighted sum of number of page fetches and RSS calls
- Each user could be provided a three-level lock system as part of Locking sub-system.

End of Phase 2 (1978 – 1980)

Functionality	Phase 0	Phase 1	Phase 2
Access Method	XRM	RSS,RDS	RSS,RDS
Concurrency	Single User	Multiple User	Multiple User
Lock Method	N/A	Intention Locks, Exclusive Locks	Three Level Locking
Recovery	N/A	w.r.t. Disk, System, Transaction failures	Shadow Page and Log Mechanism
Query Complexity	Supports Subquery but not “Join”	Joins were introduced	Subqueries, Joins , Outer Join need was proposed
Host- Capability	Standalone Query Interface	Supported PL/I , Cobol, Standalone QI (Called UFI)	Supported PL/I , Cobol, Standalone QI (Called UFI)
Security	N/A	Views were introduced	Need of Groups was proposed
Compilation Approach	N/A	Introduced	Was a big hit in System R

Bringing Theory to practice

High Level Query Language was introduced

System Research in “Action”

Macro : Design a complete system architecture

Micro : Identify key problems and provide solutions

Contributions of System R- Our Views

Thankyou !