

CSE 311 Foundations of Computing I

Lecture 22
Relations, Database
Autumn 2012

Announcements

- Reading assignments
 - 7th Edition, Sections 9.3 and 13.3
 - 6th Edition, Section 8.3 and 12.3
 - 5th Edition, Section 7.3 and 11.3

Lecture highlights



Let A and B be sets,
A **binary relation from A to B** is a subset of $A \times B$

$S \circ R = \{(a, c) \mid \exists b \text{ such that } (a,b) \in R \text{ and } (b,c) \in S\}$

$R^1 = R; \quad R^{n+1} = R^n \circ R$

Matrix and graph representation of relations

Paths in relations

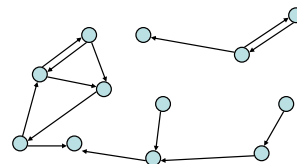
Let R be a relation on a set A. There is a path of length n from a to b if and only if $(a,b) \in R^n$

Connectivity relation

Let R be a relation on a set A. The connectivity relation R^* consists of the pairs (a,b) such that there is a path from a to b in R.

$$R^* = \bigcup_{k=0}^{\infty} R^k$$

Transitive-Reflexive Closure



Add the minimum possible number of edges to make the relation transitive and reflexive

The transitive-reflexive closure of a relation R is the connectivity relation R^*

How is  related to  ?

Anderson Copernicus

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How is  related to  ?

Suciu Copernicus

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<http://genealogy.math.ndsu.nodak.edu/>

Mathematics Genealogy Project

Edward Delano Lazowska
[MathSciNet](#)
 Ph.D. University of Toronto 1977 
 Dissertation: *Characterizing Service Time and Response Time Distributions in Queueing Network Models of Computer Systems*
 Advisor: [Kenneth Clem Sevick](#)

Students:
 Click [here](#) to see the students listed in chronological order.

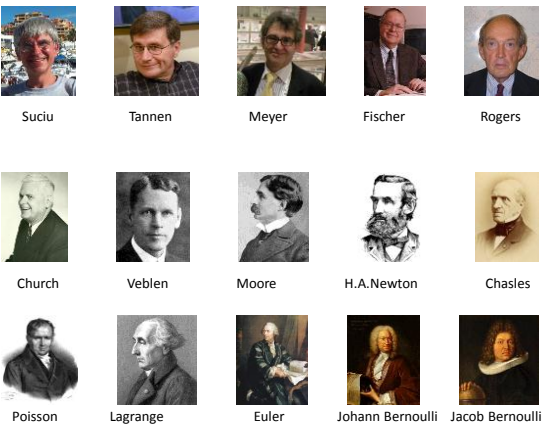
Name	School	Year	Descendants
Thomas Anderson	University of Washington	1991	54
Robert Bedichuk	University of Washington	1994	
John Bennett	University of Washington	1988	9
Brian Bershad	University of Washington	1990	16
Jeffrey Chase	University of Washington	1995	7
Sung Chung	University of Washington	1990	
Edward Felten	University of Washington	1993	8
Richard Garner	University of Washington	1982	
Patricia Jacobson	University of Washington	1984	
Henry (Hank) Levy	University of Washington	1981	123
Yi-Hing Lin	University of Washington	1990	13

Service of the NDSU Department of Mathematics, in association with the American Mathematical Society. Please email us with feedback.

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Anderson Mayr Bauer Caratheodory Minkowski Klein
 Lipschitz Dirichlet Fourier Lagrange Euler
 Johann Bernoulli Jacob Bernoulli Leibniz Weigel Rheticus Copernicus



Suciu Tannen Meyer Fischer Rogers
 Church Veblen Moore H.A. Newton Chasles
 Poisson Lagrange Euler Johann Bernoulli Jacob Bernoulli

Nicolaus Copernicus	Nicolaus Copernicus
Georg Rheticus	Georg Rheticus
Moritz Steinmetz	Moritz Steinmetz
Christoph Meurer	Christoph Meurer
Philipp Muller	Philipp Muller
Erhard Weigel	Erhard Weigel
Gottfried Leibniz	Gottfried Leibniz
Noclas Malebranache	Noclas Malebranache
Jacob Bernoulli	Jacob Bernoulli
Johann Bernoulli	Johann Bernoulli
Leonhard Euler	Leonhard Euler
Joseph Lagrange	Joseph Lagrange
Jean-Baptiste Fourier	Michel Chasles
Gustav Dirichlet	H. A. (Hubert Anson) Newton
Rudolf Lipschitz	E. H. (Eliakim Hastings) Moore
Felix Klein	Oswald Veblen
C. L. Ferdinand Lindemann	Alonzo Church
Herman Minkowski	Hartley Rogers, Jr.
Constantin Caratheodory	Patrick Carl Fischer
Georg Aumann	Albert Ronald da Silva Meyer
Friedrich Bauer	Val Tannen
Manfred Paul	Dan Suciu
Ernst Mayr	
Richard Anderson	

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n-ary relations

Let A_1, A_2, \dots, A_n be sets. An n-ary relation on these sets is a subset of $A_1 \times A_2 \times \dots \times A_n$.

Relational databases

STUDENT

Student_Name	ID_Number	Office	GPA
Knuth	328012098	022	4.00
Von Neuman	481080220	555	3.78
Russell	238082388	022	3.85
Einstein	238001920	022	2.11
Newton	1727017	333	3.61
Karp	348882811	022	3.98
Bernoulli	2921938	022	3.21

Relational databases

STUDENT

Student_Name	ID_Number	Office	GPA	Course
Knuth	328012098	022	4.00	CSE311
Knuth	328012098	022	4.00	CSE351
Von Neuman	481080220	555	3.78	CSE311
Russell	238082388	022	3.85	CSE312
Russell	238082388	022	3.85	CSE344
Russell	238082388	022	3.85	CSE351
Newton	1727017	333	3.61	CSE312
Karp	348882811	022	3.98	CSE311
Karp	348882811	022	3.98	CSE312
Karp	348882811	022	3.98	CSE344
Karp	348882811	022	3.98	CSE351
Bernoulli	2921938	022	3.21	CSE351

What wrong?

Relational databases

STUDENT

Student_Name	ID_Number	Office	GPA
Knuth	328012098	022	4.00
Von Neuman	481080220	555	3.78
Russell	238082388	022	3.85
Einstein	238001920	022	2.11
Newton	1727017	333	3.61
Karp	348882811	022	3.98
Bernoulli	2921938	022	3.21

TAKES

ID_Number	Course
328012098	CSE311
328012098	CSE351
481080220	CSE311
238082388	CSE312
238082388	CSE344
238082388	CSE351
1727017	CSE312
348882811	CSE311
348882811	CSE312
348882811	CSE344
348882811	CSE351
2921938	CSE351

Better

Database Operations: Projection

Find all offices: $\Pi_{\text{Office}}(\text{STUDENT})$

Office
022
555
333

Find offices and GPAs: $\Pi_{\text{Office,GPA}}(\text{STUDENT})$

Office	GPA
022	4.00
555	3.78
022	3.85
022	2.11
333	3.61
022	3.98
022	3.21

Database Operations: Selection

Find students with GPA > 3.9 : $\sigma_{\text{GPA} > 3.9}(\text{STUDENT})$

Student_Name	ID_Number	Office	GPA
Knuth	328012098	022	4.00
Karp	348882811	022	3.98

Retrieve the name and GPA for students with GPA > 3.9 :

$\Pi_{\text{Student_Name,GPA}}(\sigma_{\text{GPA} > 3.9}(\text{STUDENT}))$

Student_Name	GPA
Knuth	4.00
Karp	3.98

Database Operations: Natural Join

Student \bowtie Takes

Student_Name	ID_Number	Office	GPA	Course
Knuth	328012098	022	4.00	CSE311
Knuth	328012098	022	4.00	CSE351
Von Neuman	481080220	555	3.78	CSE311
Russell	238082388	022	3.85	CSE312
Russell	238082388	022	3.85	CSE344
Russell	238082388	022	3.85	CSE351
Newton	1727017	333	3.61	CSE312
Karp	348882811	022	3.98	CSE311
Karp	348882811	022	3.98	CSE312
Karp	348882811	022	3.98	CSE344
Karp	348882811	022	3.98	CSE351
Bernoulli	2921938	022	3.21	CSE351

Disambiguating Attribute Names

Names of students who share an office with Einstein:

$\Pi_{\text{STUDENT1.Student_Name}}(\text{STUDENT1} \bowtie_{\text{STUDENT1.Office = STUDENT2.Office}} (\sigma_{\text{Student_Name}=\text{Einstein}}(\text{STUDENT})))$

STUDENT					STUDENT				
Student_Name	ID_Number	Office	GPA		Student_Name	ID_Number	Office	GPA	
Knuth	328012098	022	4.00		Knuth	328012098	022	4.00	
Von Neuman	481080220	555	3.78		Von Neuman	481080220	555	3.78	
Russell	238082388	022	3.85		Russell	238082388	022	3.85	
Einstein	238001920	022	2.11		Einstein	238001920	022	2.11	
Newton	1727017	333	3.61		Newton	1727017	333	3.61	
Karp	348882811	022	3.98		Karp	348882811	022	3.98	
Bernoulli	2921938	022	3.21		Bernoulli	2921938	022	3.21	

Answer:

Student_Name
Knuth
Russell
Einstein
Karp
Bernoulli

Database Operations: Relational Algebra

Find the names and GPAs of all students who take 311

Find the names of all students who take at least two courses

Database Operations: SQL

Find the names and GPAs of all students who take 311

```
SELECT DISTINCT Student_name, GPA
FROM STUDENT Natural Join TAKES
WHERE Course = 'CSE311'
```

Find the names of all students who take at least two courses

```
SELECT DISTINCT Student_name, GPA
FROM STUDENT s, TAKES t1, TAKES t2
WHERE s.ID_number = t1.ID_number
and s.ID_number = t2.ID_number
and t1.course != t2.course
```

Relational Databases: Keys

- An attribute is a **key** if all its values in the database are always distinct

Student_Name	ID_Number	Office	GPA
Knuth	328012098	022	4.00
Von Neuman	481080220	555	3.78
Russell	238082388	022	3.85
Einstein	238001920	022	2.11
Newton	1727017	333	3.61
Karp	348882811	022	3.98
Bernoulli	2921938	022	3.21

Which attribute is the key?
Why is Student_Name not a key?

Relational Databases: Relationships

STUDENT

Student_Name	ID_Number	Office
Knuth	328012098	022
Von Neuman	481080220	555
Russell	238082388	022
Einstein	238001920	022
Newton	1727017	333
Karp	348882811	022
Bernoulli	2921938	022

PROJECT

PRJ_ID	Project_Name	Due_date
P331	"Flying cyphers"	11/2012
P004	"Virtual induction"	12/2012
P901	"Binary bots"	12/2012

WORKS_ON is a relationship between students and project

ID_Number	PRJ_ID
2921938	P004
2921938	P901
1727017	P901

Who works on what?

Types of Relationships in Relational Databases

- one-one:



- many-one



- many-many



What type is WORKS_ON?

ID_Number	PRJ_ID
2921938	P004
2921938	P901
1727017	P901