Product ($\times$)

- Example:

  $U = S \times T$

- Procedure for constructing result
  - Pair each tuple s of S with each tuple t of T
  - Concatenation of "st" is a tuple of U
  - Schema of U consists of the attributes of S and then T, in that order
  - In case attribute A has the same name in both S and T, we differentiate by writing S.A and T.A
- Schemas on either side of "=" will not match

Product ($\times$): Example

S

A	B
1	2
3	4

T

B	C
5	6
7	8
9	10

$U = S \times T$

A	S.B	T.B	C
1	2	5	6
1	2	7	8
1	2	9	10
3	4	5	6
3	4	7	8
3	4	9	10

Renaming (ρ)

- Example:

  $\rho_{R2(A1,...,An)}(R1)$

- The operator's application results in a relation named R2 with a modified schema relative to R1
- R1's value is used to build the new relation R2 but with the attributes in R2 named as listed in A1,...,An
- The attribute names usually differ from the original relation's
  - But they have the same number (i.e., there is no projection)
  - And there is nothing which requires all attribute names to differ from the original

Renaming (ρ): Example

Pubs

name	addr	URL
Rob's	Fort	http://robsplace.com
Pat's	Broughton	http://patspub.ca

ρ ModPubs(pubname, location, web) Pubs

ModPubs

pubname	location	web
Rob's	Fort	http://robsplace.com
Pat's	Broughton	http://patspub.ca

Bit of a breather

- We now have all of the straightforward operators
- One of them is used to combine together two relations (product)
- However:
  - Using our operators so far to pose non-trivial questions of relations can be painful
  - For example, we may often be interested in relations that share the same attributes
- Example: Find the URLs of all pubs that sell "Blue Buck" for less than 3.00

Bit of a breather

- Example: Find the URLs of all pubs that sell "Blue Buck" for less than 3.00
  - **Sells** relation has attributes for **pubs**, **beers** and **prices**
  - **Pubs** relation has attributes for **names**, **addresses** and **URL**
  - Need to somehow link up the tuples we want from **Sells** with the information contained in **Pub**

Bit of a breather

Find the URLs of all pubs that sell "Blue Buck" for less than 3.00

Sells

pub	beer	price
Rob's	Amnesiac	7.50
Rob's	Blue Buck	3.25
Pat's	Amnesiac	7.50
Pat's	Blue Buck	2.95

Pubs

name	addr	URL
Rob's	Fort	http://robsplace.com
Pat's	Broughton	http://patspub.ca

(we want)

URL
http://patspub.ca

Bit of a breather

- We will (frequently!) need to combine relations
- A common thread:
  - Relations to be combined together either have shared attribute names...
  - ... or we can rename attributes so that sharing occurs
- Rather than using σ, $\times$, π and ρ all the time, we can instead use a **join operator.**

Theta Join ($\bowtie_C$)

- Example:

  R3 = R1 $\bowtie_C$ R2

- Procedure for constructing result
  - Take the product of R1 and R2 (R1 $\times$ R2)
  - Then apply σ_C to the result
- As with σ, the condition C in a theta-join can be any boolean-valued expression
- (Schema of the result?)

Theta-join ($\bowtie_c$): Example

Sells

pub	beer	price
Rob's	Amnesiac	7.50
Rob's	Blue Buck	3.25
Pat's	Amnesiac	7.50
Pat's	Blue Buck	2.95

Pubs

name	addr	URL
Rob's	Fort	http://robsplace.com
Pat's	Broughton	http://patspub.ca

PubInfo = Sells $\bowtie_{\text{Sells.pub} = \text{Pubs.name}}$ Pubs = ???

Theta-join ($\bowtie_c$): Example

PubInfo = Sells $\bowtie_{\text{Sells.pub} = \text{Pubs.name}}$ Pubs

pub	beer	price	name	addr	URL
Rob's	Amnesiac	7.50	Rob's	Fort	http://robsplace.com
Rob's	Blue Buck	3.25	Rob's	Fort	http://robsplace.com
Pat's	Amnesiac	7.50	Pat's	Broughton	http://patspub.ca
Pat's	Blue Buck	2.95	Pat's	Broughton	http://patspub.ca

Natural Join (⋈)

- Example:

  R3 = R1 ⋈ R2

- This is the most used type of join
- Connects two relations by the following procedure:
  - Pairs of attributes from tuples having the same name are compared for equality.
  - Only those tuples where such attributes are equal will be kept.
  - One copy of each pair is projected out of the resulting set of tuples.

Natural Join (⋈): Example

Sells

pub	beer	price
Rob's	Amnesiac	7.50
Rob's	Blue Buck	3.25
Pat's	Amnesiac	7.50
Pat's	Blue Buck	2.95

Pubs

name	addr	URL
Rob's	Fort	http://robsplace.com
Pat's	Broughton	http://patspub.ca

Pubs'

pub	addr	URL
Rob's	Fort	http://robsplace.com
Pat's	Broughton	http://patspub.ca

Natural Join (⋈): Example

Sells

pub	beer	price
Rob's	Amnesiac	7.50
Rob's	Blue Buck	3.25
Pat's	Amnesiac	7.50
Pat's	Blue Buck	2.95

Pubs'

pub	addr	URL
Rob's	Fort	http://robsplace.com
Pat's	Broughton	http://patspub.ca

PubInfo = Sells ⋈ Pubs = ???

Natural Join (⋈): Example

PubInfo = Sells ⋈ Pubs

PubInfo

pub	beer	price	addr	URL
Rob's	Amnesiac	7.50	Fort	http://robsplace.com
Rob's	Blue Buck	3.25	Fort	http://robsplace.com
Pat's	Amnesiac	7.50	Broughton	http://patspub.ca
Pat's	Blue Buck	2.95	Broughton	http://patspub.ca