CSE 4125: Distributed Database Systems
Chapter – 6
(Part – D)

Optimization of Access Strategies.

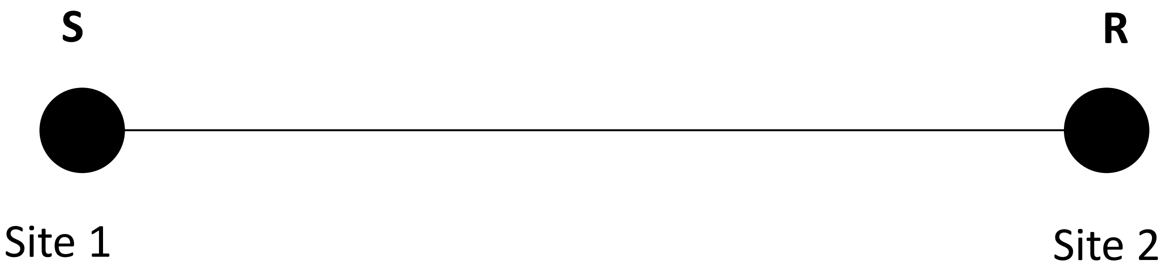
Semi-join Programs
(Join using Semi-join)

Semi-join Programs

$$\boldsymbol{R}\ \mathrm{JN}_{\mathrm{C=A}}\ \boldsymbol{S} \leftrightarrow (\boldsymbol{R}\ \mathrm{SJ}_{\mathrm{C=A}}\ \mathrm{PJ}_{\mathrm{A}}\ \boldsymbol{S})\ \mathrm{JN}_{\mathrm{C=A}}\ \boldsymbol{S}$$

Assume, $C_0 = 0$, $C_1 = 1$, $\rho = 0.2$
Size(A) = Size(B) = Size(C) = Size(D) = 2 bytes

A	B
1	4
2	5
3	6
3	7

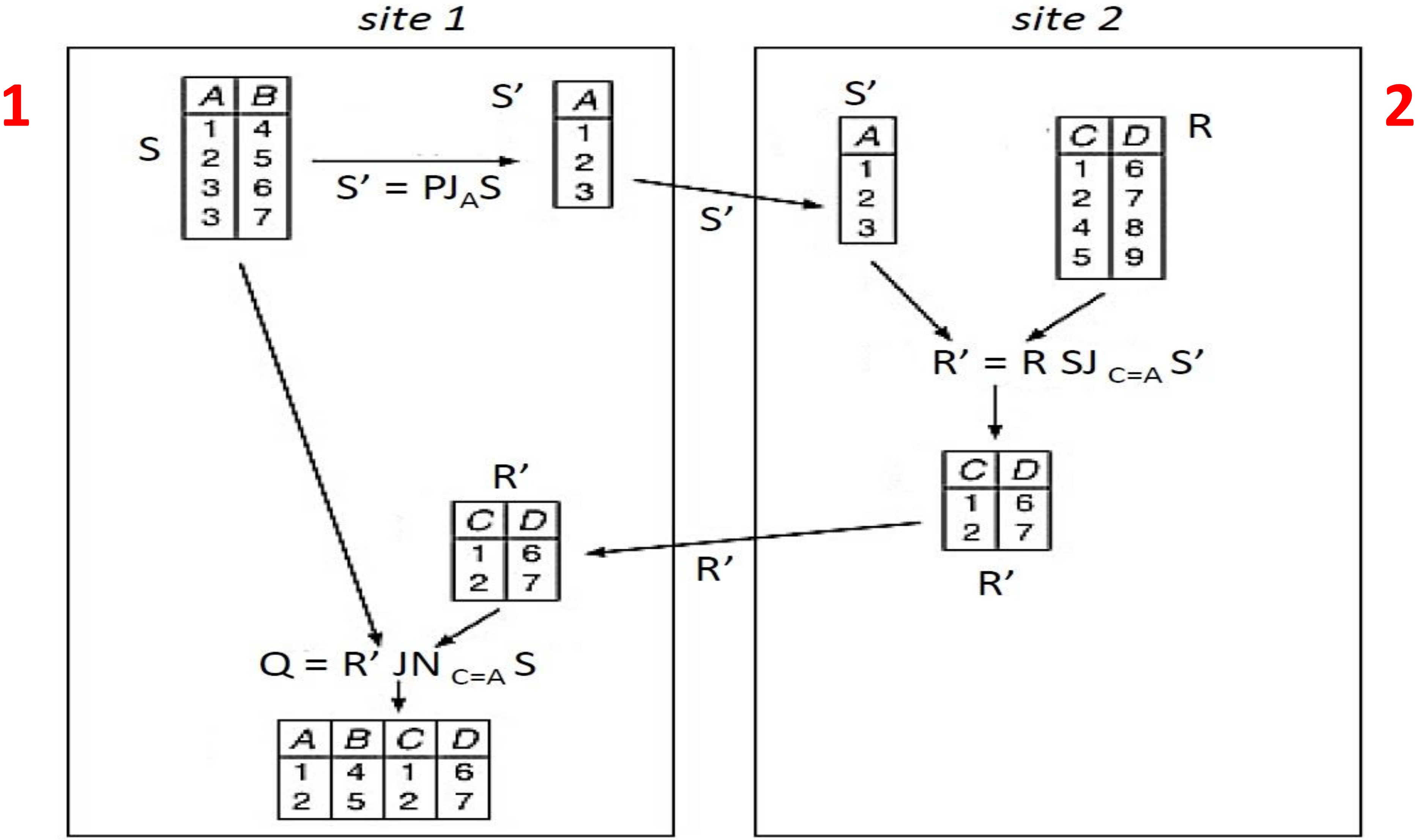


C	D
1	6
2	7
4	8
5	9

We want to perform $\boldsymbol{R}$ $\mathrm{JN}_{\mathrm{C=A}}$ $\boldsymbol{S}$ at site – 1 using Semi-Join Program.

Semi-join Programs (cont.)

$\boldsymbol{R}\ \mathrm{JN}_{C=A}\ \boldsymbol{S} \leftrightarrow (\boldsymbol{R}\ \mathrm{SJ}_{C=A}\ \mathrm{PJ}_{A}\ \boldsymbol{S})\ \mathrm{JN}_{C=A}\ \boldsymbol{S}$



1

site 1

S

A	B
1	4
2	5
3	6
3	7

$S' = PJ_A S$

S′

A
1
2
3

S′

2

site 2

S′

A
1
2
3

R

C	D
1	6
2	7
4	8
5	9

$R' = R\ SJ_{C=A}\ S'$

C	D
1	6
2	7

R′

R′

R′

C	D
1	6
2	7

$Q = R'\ JN_{C=A}\ S$

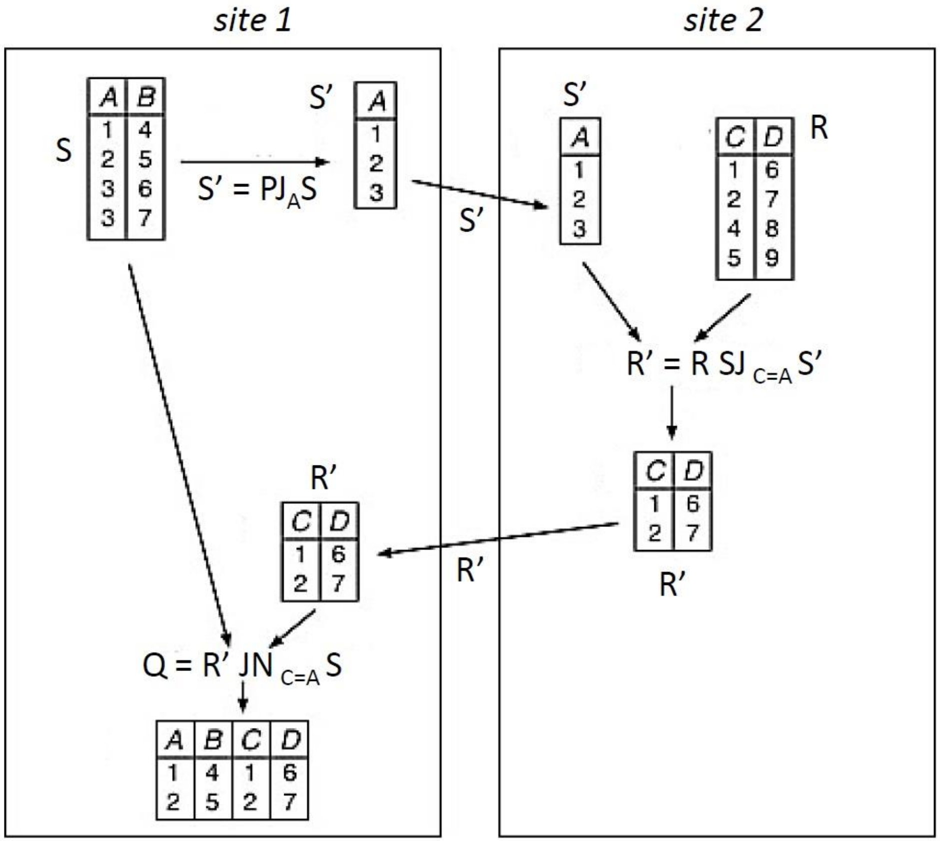
A	B	C	D
1	4	1	6
2	5	2	7

Semi-join Programs (cont.)

Steps of Semi-join program

1. Send **S' = PJ$_A$ (S)** to **site-2**
2. Compute **R' = R SJ$_{C=A}$** **S'** at **site-2**
3. Send **R'** to **site-1**
4. Compute **Q = R' JN$_{C=A}$ S** at **site-1**

***Task**: What will be the steps if we want to perform the join at site 2?*



A	B
1	4
2	5
3	6
3	7

A
1
2
3

C	D
1	6
2	7
4	8
5	9

C	D
1	6
2	7

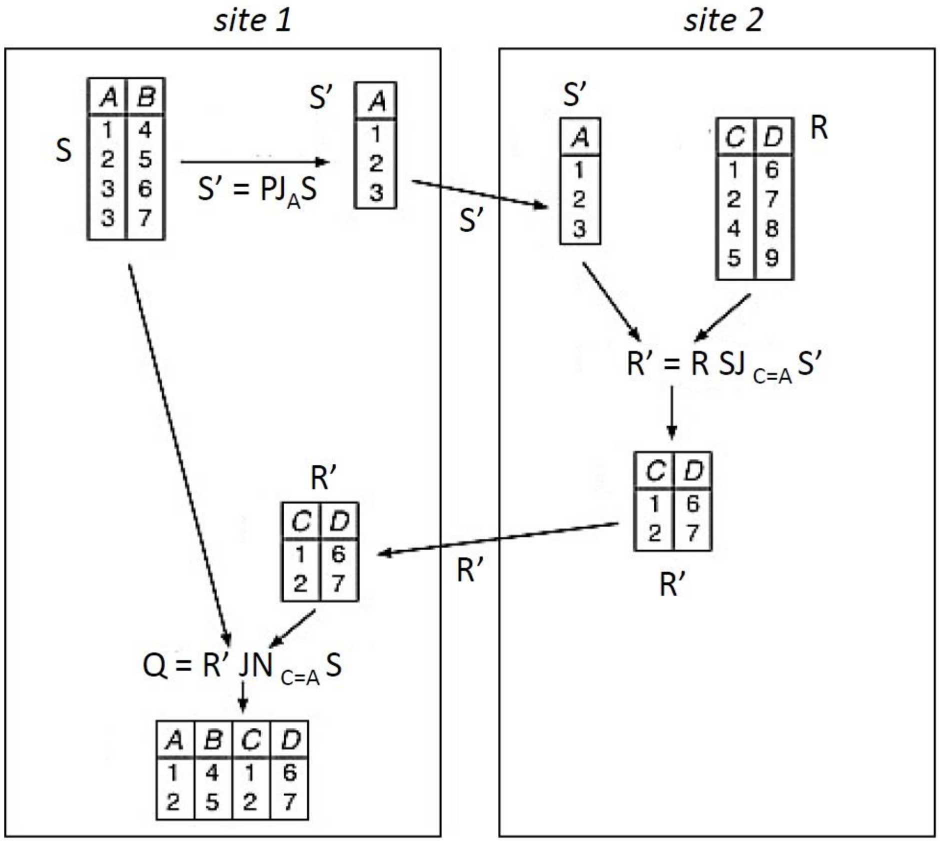
A	B	C	D
1	4	1	6
2	5	2	7

Semi-join Programs (cont.)

Cost of Semi-join program

Step 1: Send **S' = PJ$_A$ (S)** to **site-2**

$$
\begin{aligned}
TC_1 &= C_0 + C_1 * x \\
&= C_0 + C_1 * Card(S') * size(S') \\
&= C_0 + C_1 * val(A[S]) * size(A) \\
&= 0 + 1 * 3 * 2 \text{ bytes} \\
&= 6 \text{ bytes} \\
&= 6 * 8 \text{ bits} \\
&= 48 \text{ bits}
\end{aligned}
$$



A	B
1	4
2	5
3	6
3	7

A
1
2
3

A
1
2
3

C	D
1	6
2	7
4	8
5	9

C	D
1	6
2	7

C	D
1	6
2	7

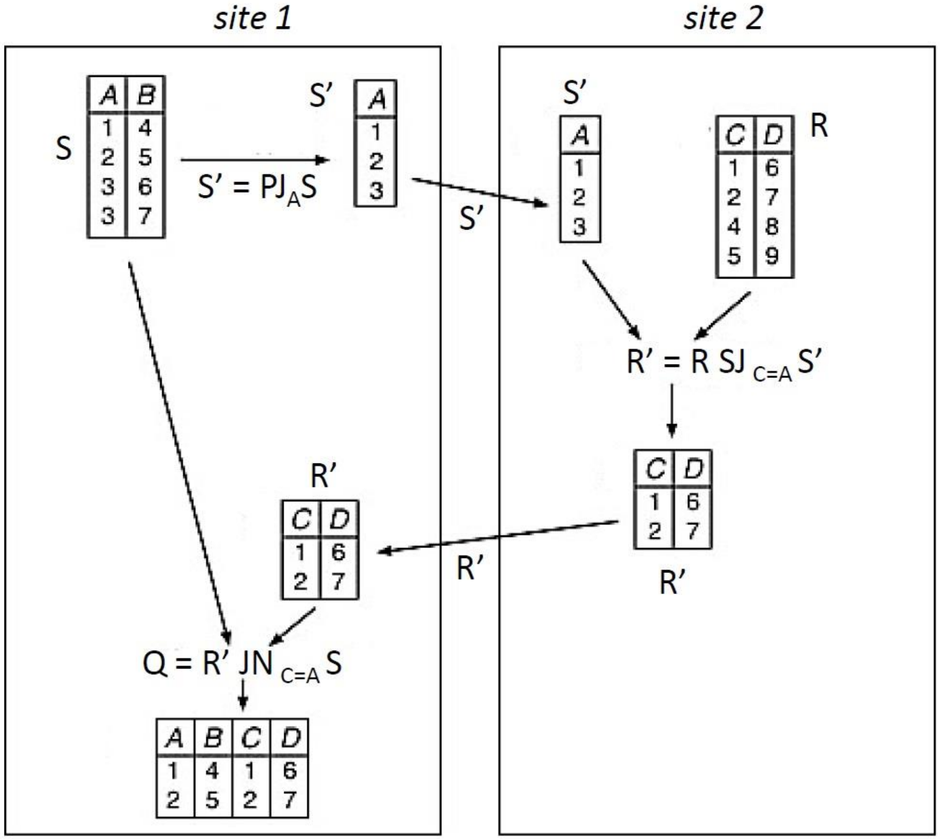
A	B	C	D
1	4	1	6
2	5	2	7

Semi-join Programs (cont.)

Cost of Semi-join program

Step 2: Compute **R’ = R JN$_{C=A}$ S’** at **site-2**

TC$_2$ = 0



S

A	B
1	4
2	5
3	6
3	7

S’

A
1
2
3

R

C	D
1	6
2	7
4	8
5	9

R’

C	D
1	6
2	7

Q

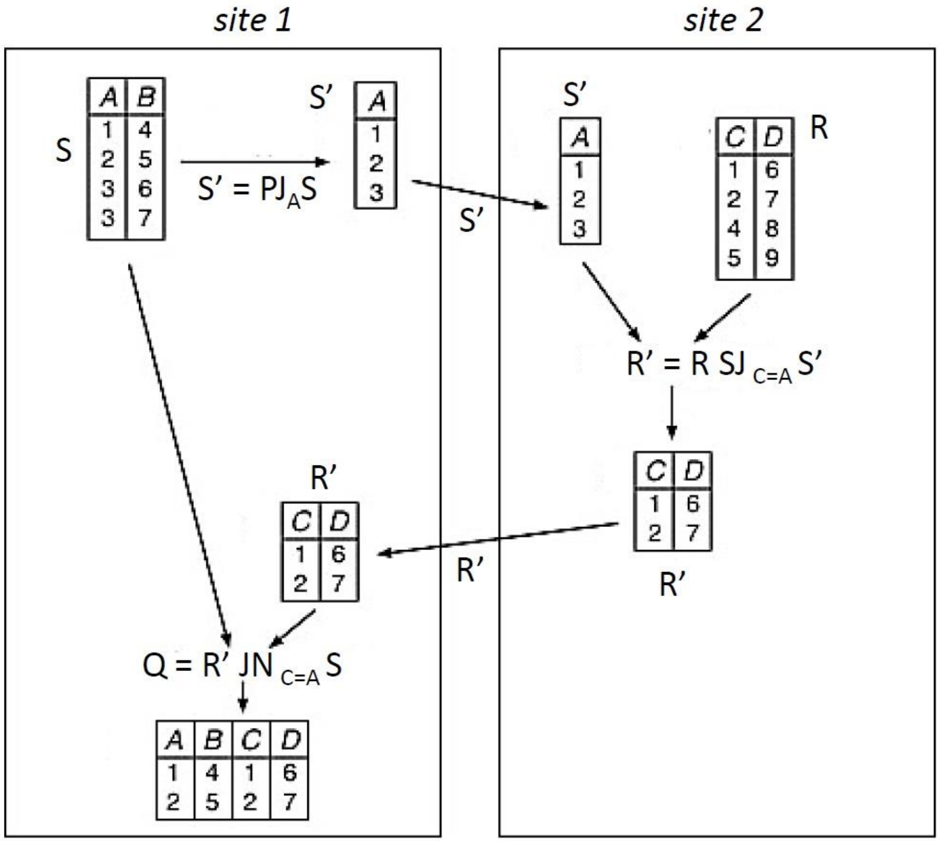
A	B	C	D
1	4	1	6
2	5	2	7

Semi-join Programs (cont.)

Cost of Semi-join program

Step 3: Send **R’** to **site-1**

$$
\begin{aligned}
\mathrm{TC}_3 &= C_0 + C_1 * x \\
&= C_0 + C_1 * Card(R') * size(R') \\
&= C_0 + C_1 * \rho * Card(R) * size(R) \\
&= 0 + 1 * 0.2 * 4 * 4 \ bytes \\
&= 3.2 \text{ bytes} \\
&= 3.2 * 8 \text{ bits} \\
&= 25.6 \text{ bits} \\
&\approx 26 \ bits
\end{aligned}
$$



A	B
1	4
2	5
3	6
3	7

A
1
2
3

C	D
1	6
2	7
4	8
5	9

C	D
1	6
2	7

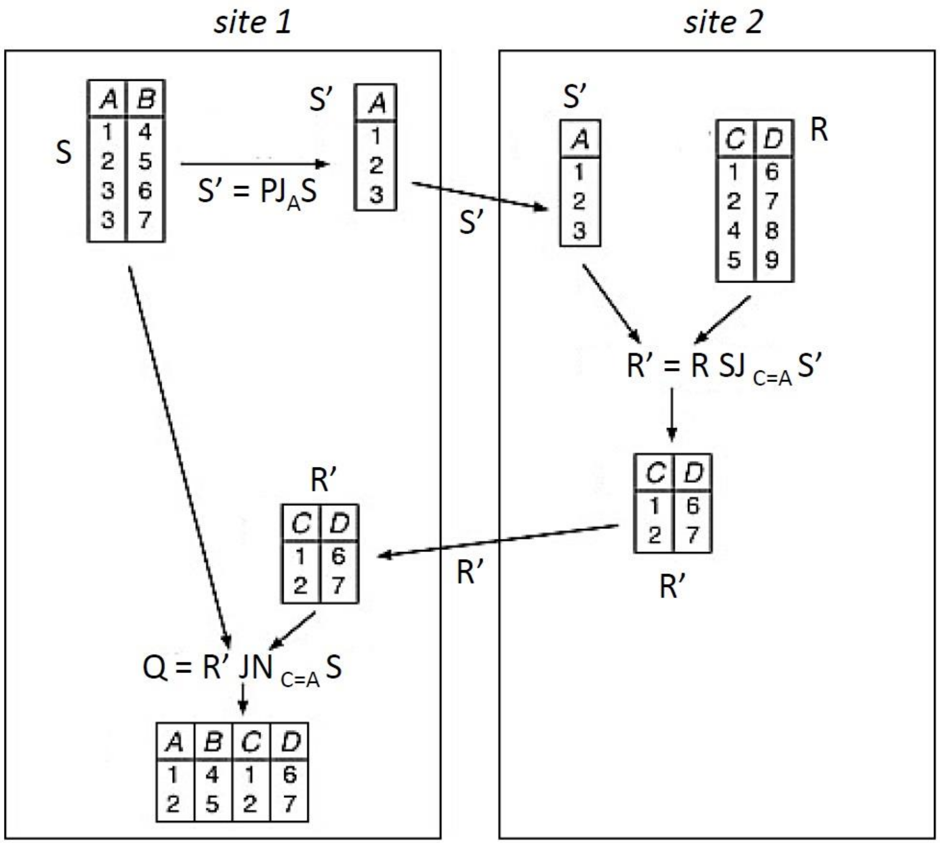
A	B	C	D
1	4	1	6
2	5	2	7

Semi-join Programs (cont.)

Cost of Semi-join program

Step 4: Compute **Q = R' JN$_{C=A}$ S** at **site-1**

$TC_4 = 0$



S

A	B
1	4
2	5
3	6
3	7

S'

A
1
2
3

R

C	D
1	6
2	7
4	8
5	9

R'

C	D
1	6
2	7

Q

A	B	C	D
1	4	1	6
2	5	2	7

Semi-join Programs (cont.)

Cost of Semi-join program

Total cost

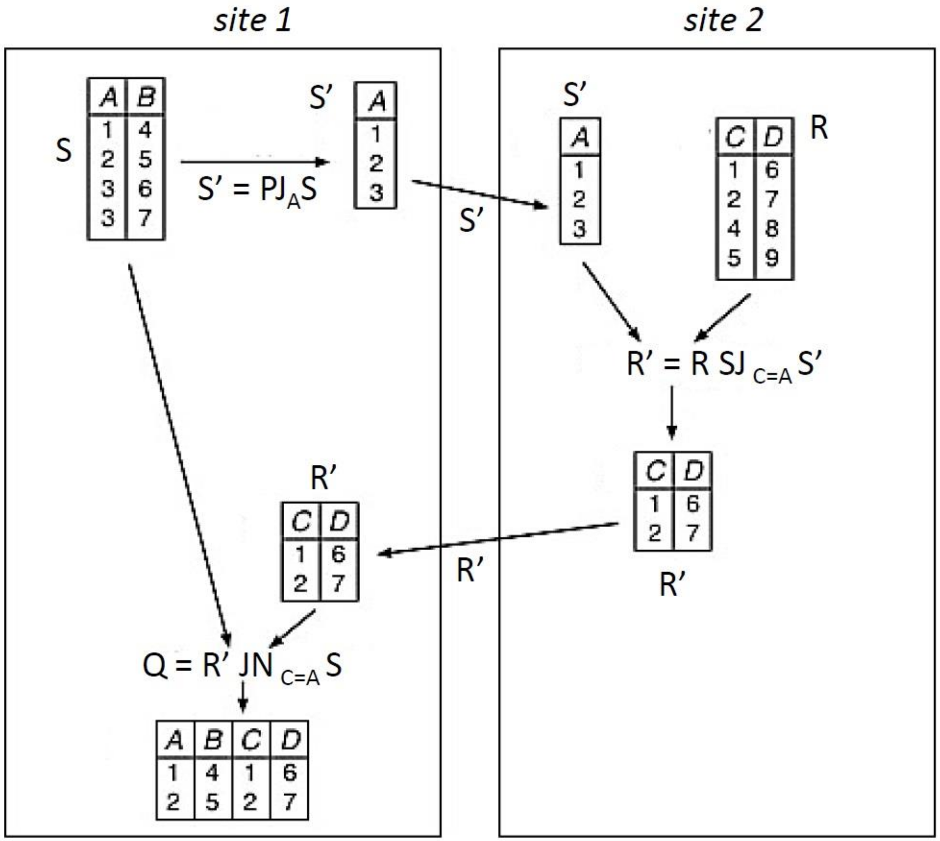
$TC_{SJ} = TC_1 + TC_2 + TC_3 + TC_4 = 48 + 0 + 26 + 0 = 74$ bits

If $TC_{SJ} < TC_{JN}$ then semi-join program is profitable.

Semi-join Programs (cont.)

Cost without Semi-join program

$$\begin{aligned}TC_{JN} &= C_0 + C_1 * x \\ &= C_0 + C_1 * Card(R) * size(R) \\ &= 0 + 1 * 4 * 4 \text{ bytes} \\ &= 16 \text{ bytes} \\ &= 16 * 8 \text{ bits} \\ &= 128 \text{ bits}\end{aligned}$$



S

A	B
1	4
2	5
3	6
3	7

S'

A
1
2
3

R

C	D
1	6
2	7
4	8
5	9

R'

C	D
1	6
2	7

A	B	C	D
1	4	1	6
2	5	2	7

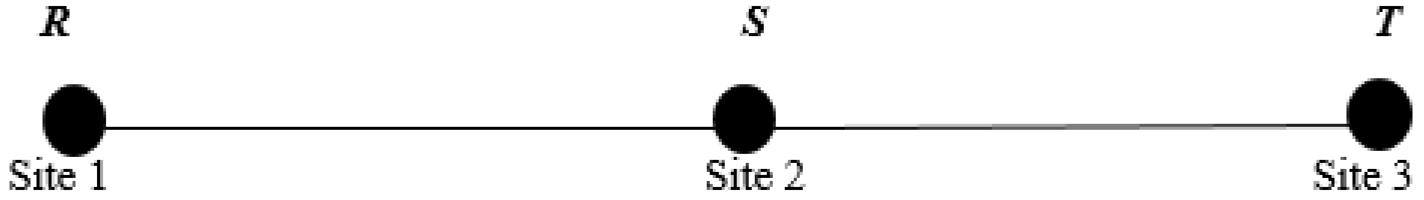
Other Applications of Semi-join Programs

- ❑ Semi-join programs can be used as fragment reducers (operations that can reduce cardinality of a relation).
  - –Similarly to unary operations.

- ❑ Full reducer:
  - –Chain of semi-joins.

Exercise

Consider the following distributed database with relations **R**, **S** and **T** over a network of site 1, 2 and 3.



Assume the following specifications are given.

$$C_0^{12} = C_0^{23} = C_1^{21} = C_1^{32} = 0\ unit$$

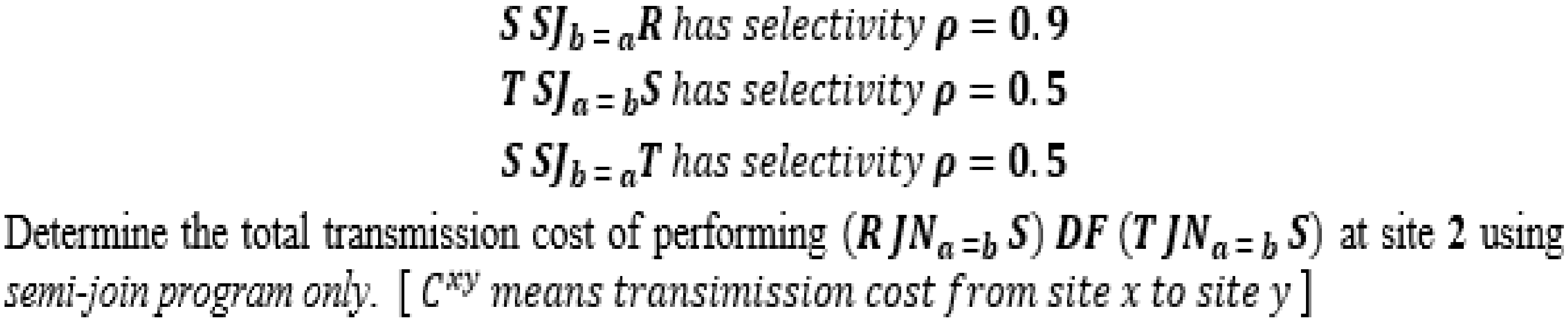
$$C_1^{12} = C_1^{23} = C_0^{21} = C_0^{32} = 1\ unit$$

size (R) = 20 bytes, **size(T)** = 20 bytes, **size(S)** = 40 bytes, **size(a)** = **size(b)** = 1 byte

card(R) = 100, **card(S)** = 50, **card(T)** = 50

val(a[R]) = **val(b[S])** = **val(a[T])** = 50

$\boldsymbol{R\ SJ_{a\,=\,b}S}$ $has\ selectivity$ $\boldsymbol{\rho = 0.1}$



$$\boldsymbol{S\ SJ_{b\,=\,a}R}\ \textit{has selectivity}\ \boldsymbol{\rho = 0.9}$$

$$\boldsymbol{T\ SJ_{a\,=\,b}S}\ \textit{has selectivity}\ \boldsymbol{\rho = 0.5}$$

$$\boldsymbol{S\ SJ_{b\,=\,a}T}\ \textit{has selectivity}\ \boldsymbol{\rho = 0.5}$$

Determine the total transmission cost of performing $(\boldsymbol{R\ JN_{a\,=b}\ S})\ \boldsymbol{DF}\ (\boldsymbol{T\ JN_{a\,=\,b}\ S})$ at site **2** using *semi-join program only*. [C^{xy} *means transimission cost from site x to site y*]