Relational Algebra
Expressions = Queries

Relational Algebra Operators

- Projection **π**
- Selection **σ**
- Duplicate elimination **δ**
- Sorting **τ**
- GroupBy aggregations **γ**
- Set operations **U, ∩, -**
- Product **x**
- Join **⋈**

- Every operator takes as input one or two tables and generates as output a table
  - Schema
  - Tuples
- Operators are composable
  - The output of one operator is the input of another operator

Relational Algebra Expressions

- Sequence of relational algebra operators
  - Input is a set of tables
  - Output is the result table
- **Relational algebra expression = Query**
- This is exactly how PANDAS work
- Arithmetic algebra mixed operations

  4 * (7 – (2 + 3)) – 6 + 5 * 6

2.4.1 a)

- Projection **π**
- Selection **σ**
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- Set operations **U, ∩, -**
- Product **x**
- Join ⋈

- $S_1(M,S,R,H,P) = \sigma_{S>=3}(PC(M,S,R,H,P))$

  $R(model) = \pi_M(S_1(M,S,R,H,P))$
- $R(model) = \pi_{model}(\sigma_{speed>=3}(PC))$

2.4.1 b)

- Projection **π**
- Selection **σ**
- Duplicate elimination **δ**
- Sorting **τ**
- GroupBy aggregations **γ**
- Set operations **U, ∩, -**
- Product **x**
- Join **⋈**

- $S_1(M,S,R,H,Sc,P) = \sigma_{H>=100}(Laptop(M,S,R,H,Sc,P))$

  $S_2(Ma,M,T,S,R,H,Sc,P) = Product(Ma,M,T) \bowtie S_1(M,S,R,H,Sc,P)$

  $R(maker) = \pi_{Ma}(S_2(Ma,M,T,S,R,H,Sc,P))$
- $R(maker) = \pi_{maker}(Product \bowtie \sigma_{hd>=100}(Laptop))$

2.4.1 c)

- Projection **π**
- Selection **σ**
- Duplicate elimination **δ**
- Sorting **τ**
- GroupBy aggregations **γ**
- Set operations **U, ∩, -**
- Product **x**
- Join ⋈

- $S_1(\text{model,price}) = \pi_{\text{model,price}}(\sigma_{\text{maker='B'}}(\text{Product}) \bowtie \text{PC})$

  $S_2(\text{model,price}) = \pi_{\text{model,price}}(\sigma_{\text{maker='B'}}(\text{Product}) \bowtie \text{Laptop})$

  $S_3(\text{model,price}) = \pi_{\text{model,price}}(\sigma_{\text{maker='B'}}(\text{Product}) \bowtie \text{Printer})$

  $R(\text{model,price}) = S_1 \cup S_2 \cup S_3$

2.4.1 d)

- Projection **π**
- Selection **σ**
- Duplicate elimination **δ**
- Sorting **τ**
- GroupBy aggregations **γ**
- Set operations **U, ∩, -**
- Product **x**
- Join **⋈**

- $S_1(M,C,T,P) = \sigma_{C=true \text{ AND } T='laser'}(Printer(M,C,T,P))$

  $R(model) = \pi_M(S_1(M,C,T,P))$
- $R(model) = \pi_{model}(\sigma_{color=true \text{ AND } type='laser'}(Printer))$

2.4.1 e)

- Projection **π**
- Selection **σ**
- Duplicate elimination **δ**
- Sorting **τ**
- GroupBy aggregations **γ**
- Set operations **U, ∩, -**
- Product **x**
- Join **⋈**

- $S_1(\text{maker}) = \pi_{\text{maker}}(\sigma_{\text{type='laptop'}}(\text{Product}))$

  $S_2(\text{maker}) = \pi_{\text{maker}}(\sigma_{\text{type='pc'}}(\text{Product}))$

  $R(\text{maker}) = S_1 - S_2$

2.4.1 f)

- Projection **π**
- Selection **σ**
- Duplicate elimination **δ**
- Sorting **τ**
- GroupBy aggregations **γ**
- Set operations **U, ∩, -**
- Product **x**
- Join **⋈**

- $S_1(hd,cnt) = \gamma_{hd,\ COUNT(*)\ AS\ cnt}(PC)$

  $S_2(hd,cnt) = \sigma_{cnt>=2}(S_1)$

  $R(hd) = \pi_{hd}(S_2)$
- $R(hd) = \pi_{hd}(\sigma_{cnt>=2}(\gamma_{hd,\ COUNT(*)\ AS\ cnt}(PC)))$

2.4.1 g)

- Projection **π**
- Selection **σ**
- Duplicate elimination **δ**
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- GroupBy aggregations **γ**
- Set operations **U, ∩, -**
- Product **x**
- Join **⋈**

- $S_1(M_1,Sp_1,R_1,H_1,P_1,M_2,Sp_2,R_2,H_2,P_2) =$
  $PC \rightarrow PC_1(M_1,Sp_1,R_1,H_1,P_1)$
  $\bowtie_{Sp1=Sp2 \text{ AND } R1=R2 \text{ AND } M1<M2}$
  $PC \rightarrow PC_2(M_2,Sp_2,R_2,H_2,P_2)$

  $R(model_1,model_2) = \pi_{M1,M2}(S_1(M_1,Sp_1,R_1,H_1,P_1,M_2,Sp_2,R_2,H_2,P_2))$

2.4.1 h)

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- GroupBy aggregations **γ**
- Set operations **U, ∩, -**
- Product **x**
- Join **⋈**

- $S_1(\text{model,maker}) = \pi_{\text{model,maker}}(\text{Product} \bowtie \sigma_{\text{speed}>=2.8}(\text{PC}))$

  $S_2(\text{model,maker}) = \pi_{\text{model,maker}}(\text{Product} \bowtie \sigma_{\text{speed}>=2.8}(\text{Laptop}))$

  $S_3(\text{model,maker}) = S_1 \cup S_2$

  $S_4(\text{maker,cnt}) = \gamma_{\text{maker, COUNT(*) AS cnt}}(S_3)$

  $S_5(\text{maker,cnt}) = \sigma_{\text{cnt}>=2}(S_4)$

  $R(\text{maker}) = \pi_{\text{maker}}(S_5)$

2.4.1 i)

- Projection **π**
- Selection **σ**
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- Sorting **τ**
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- Set operations **U, ∩, -**
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- Join **⋈**

- $S_1(model,speed) = \pi_{model,speed}(PC)$

  $S_2(model,speed) = \pi_{model,speed}(Laptop)$

  $S_3(model,speed) = S_1 \cup S_2$

  $S_4(M_1,Sp_1,M_2,Sp_2) = S_3 \rightarrow S_{31}(M_1,Sp_1) \bowtie_{Sp1<Sp2 \text{ AND } M1<M2} S_3 \rightarrow S_{32}(M_2,Sp_2)$

  $S_5(model) = \pi_{M1}(S_4(M_1,Sp_1,M_2,Sp_2))$

  $S_6(model) = \pi_{model}(S_1) \cup \pi_{model}(S_2)$

  $S_7 = S_6 - S_5$

  $R(maker) = \pi_{maker}(Product \bowtie S_7)$

2.4.1 j)

- Projection **π**
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- Set operations **U, ∩, -**
- Product **x**
- Join **⋈**

- $S_1(\text{maker,speed}) = \pi_{\text{maker,speed}}(\text{Product} \bowtie \text{PC})$

  $S_2 = \boldsymbol{\delta}(S_1)$

  $S_3(\text{maker,cnt}) = \gamma_{\text{maker, COUNT(*) AS cnt}}(S_2)$

  $S_4(\text{maker,cnt}) = \sigma_{\text{cnt>=3}}(S_3)$

  $R(\text{maker}) = \pi_{\text{maker}}(S_4)$

2.4.1 k)

- Projection **π**
- Selection **σ**
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- Product **x**
- Join **⋈**

- $S_1(\text{maker,model}) = \pi_{\text{maker,model}}(\sigma_{\text{type='pc'}}(\text{Product}))$

  $S_2(\text{maker,cnt}) = \gamma_{\text{maker, COUNT(*) AS cnt}}(S_1)$

  $S_3(\text{maker,cnt}) = \sigma_{\text{cnt=3}}(S_2)$

  $R(\text{maker}) = \pi_{\text{maker}}(S_3)$