An Untold Story of Redundant Clouds: Making Your Service Deployment Truly Reliable

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\textsuperscript{1}Yale University & \textsuperscript{2}Bell Labs
Road-Map

- Motivations
- Goal & Insight
- iRec System
- Next Steps
Road-Map

• Motivations
• Goal & Insight
• iRec System
• Next Steps
Background

- Application providers:
  - enjoy the simplicity of using the clouds
Background

• Application providers:
  - enjoy the simplicity of using the clouds
  - have no idea about what happen in the clouds
Background

- Application providers:
  - enjoy the simplicity of using the clouds
  - have no idea about what happen in the clouds
  - rent multiple clouds for redundancy
Example 1: Netflix

Netflix Application Service

EC2 availability zone

EC2 availability zone

EC2 availability zone

IaaS

App
Example 2: iCloud

iCloud Application Service

Amazon EC2 Service

Microsoft Azure Service

App

IaaS
Problem

Cloud Provider A

Email App

Cloud Provider B
Problem

Email App

Cloud Provider A

Cloud Provider B

Third-party infrastructure components
Problem

Cloud Provider A

Cloud Provider B

Third-party infrastructure components

ISP A

ISP B

ISP C
Problem

Third-party infrastructure components

Cloud Provider A

Email App

Cloud Provider B

ISP A

ISP B

ISP C

Power Source
Problem

Cloud Provider A

Cloud Provider B

Email App

ISP A

ISP B

ISP C

Third-party infrastructure components

Power Source
Problem

Become unavailable!

Cloud Provider A

Cloud Provider B

ISP A

ISP B

ISP C

Third-party infrastructure components

Power Source
Lightning strikes Amazon's European cloud

**Summary:** The lightning strike damaged a power company's transformer, causing disruption to Amazon Web Services's European cloud, and may have affected Microsoft's BPOS as well.

The outage, which Amazon Web Services (AWS) acknowledged on Sunday evening, affected its Dublin-based Elastic Compute Cloud (EC2) and Relational Database Service (RDS) cloud services, among others. The damage to the electricity infrastructure may have affected Microsoft's Business Productivity Online Services (BPOS) cloud as well, Microsoft said in a separate statement.
Existing Efforts

- Cloud providers allocate or tolerate failures via:
  - diagnosis systems, e.g., Sherlock.
  - fault-tolerant systems, e.g., F10, Skute.
Existing Efforts

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• Solving the problem after the outage occurs
Existing Efforts

• Cloud providers allocate or tolerate failures via:
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• Solving the problem after the outage occurs

• We want to prevent the problem before the outage occurs
Existing Efforts

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• Solving the problem after the outage occurs

• We want to prevent the problem before the outage occurs

• Recommending truly independent redundancy services when deploying applications
Road-Map

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Road-Map

• Motivations

• Goal & Insight

• iRec System

• Next Steps
Goal & Insight

App Provider

Cloud A

Cloud B

Cloud C
Goal & Insight

App Provider

Select two clouds for redundancy

Cloud A  Cloud B  Cloud C
Goal & Insight

App Provider

Cloud A

Cloud B

Cloud C
Goal & Insight

App Provider: B and C?
Goal & Insight

App Provider

Cloud A

Cloud B

Cloud C

A and C?
App Provider

Goal & Insight

Select two clouds for redundancy: A&B? B&C? or A&C?

Cloud A

Cloud B

Cloud C

Recommender
Goal & Insight

App Provider → Recommender

Cloud A → Cloud B → Cloud C
Goal & Insight

Assessing independence by the # of overlapping components between clouds
Goal & Insight

App Provider

Cloud A

Recommender

Cloud B

Cloud C
Goal & Insight

App Provider

Cloud A
ISP A
Power A
Power B

Cloud B

Cloud C

Recommender

ISP A
Power A
Power B
Goal & Insight

App Provider

ISP A
Power A
Power B

Cloud A

Recommender

Cloud B

Cloud C

ISP A
Power A
Power B
Goal & Insight

App Provider

ISP A
Power A
Power B

Cloud A

ISP B

Cloud B

ISP A
Power A

Power B

Cloud C

Recommender
Goal & Insight

App Provider

ISP A
Power A
Power B

Cloud A

ISP B
Power A
Power B

Cloud B

ISP B

Cloud C

Recommender

ISP A

Power A

Power B

ISP B
Goal & Insight

App Provider

ISP A
Power A
Power B

Cloud A

ISP B
Power A
Power B

Cloud B

ISP B
Power A
Power B

Cloud C

ISP A
Power A

ISP B
Power B

ISP B
Power C
Goal & Insight

App Provider

Cloud A

ISP A
Power A
Power B

Cloud B

ISP B
Power A
Power B

Cloud C

ISP B
Power C

Recommender

ISP A
Power A

Power B

ISP B

Power C
Goal & Insight

App Provider

Cloud A

ISP A
Power A
Power B

Cloud B

ISP B
Power A
Power B

Cloud C

ISP B
Power C

Recommender

Deployment

| n |

ISP A
Power A

Power B

ISP B

Power C

Power A

Power B

ISP B

Power C
Goal & Insight

App Provider

ISP A
Power A
Power B

Cloud A

ISP B
Power A
Power B

Cloud B

ISP B
Power C

Cloud C

ISP A
Power A

Power B

ISP B

Power C
Goal & Insight

| Deployment | \(|n|\) |
|------------|------|
| Cloud A, B | 2    |

ISP A
Power A
Power B

ISP A
Power B

Cloud A

ISP B
Power A
Power B

ISP B
Power C

Cloud B

ISP B
Power B

Cloud C

ISP A
Power A

Power B

Power C
Goal & Insight

App Provider

ISP A
Power A
Power B

Cloud A

ISP B
Power A
Power B

Cloud B

ISP B
Power B

Cloud C

ISP A
Power A

ISP B
Power A

ISP B
Power C

Power B

Power C

Recommender

<table>
<thead>
<tr>
<th>Deployment</th>
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<tbody>
<tr>
<td>Cloud A, B</td>
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Goal & Insight

<table>
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<tbody>
<tr>
<td>Cloud A, B</td>
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</tbody>
</table>

ISP A
Power A
Power B

ISP B
Power A
Power B

ISP B
Power C

Cloud A

Cloud B

Cloud C

ISP A
Power A

Power B

ISP B

Power C
Goal & Insight

<table>
<thead>
<tr>
<th>Deployment</th>
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<tbody>
<tr>
<td>Cloud B, C</td>
<td>1</td>
</tr>
<tr>
<td>Cloud A, B</td>
<td>2</td>
</tr>
</tbody>
</table>

App Provider

ISP A
Power A
Cloud A

ISP A
Power A

ISP B
Power C
Cloud C

ISP B

Cloud B

ISP B

Power B

Recommended
**Goal & Insight**

| Deployment       | \( |n| \) |
|------------------|-------|
| Cloud B, C       | 1     |
| Cloud A, B       | 2     |

Cloud A, C  \( \cap \)  Cloud B, C  = 0

ISP A
Power A

Cloud A

ISP B
Power C

Cloud C
Goal & Insight

| Deployment        | |n| |
|-------------------|---|---|
| Cloud A, C        | 0 |
| Cloud B, C        | 1 |
| Cloud A, B        | 2 |

ISP A
Power A
ISP B
Power C
ISP C
Power C

Cloud A
Cloud B
Cloud C

ISP A
Power A
ISP B
Power B
App Provider

Goal & Insight

Recommender

| Deployment     | |n| |
|----------------|---|---|
| Cloud A, C     | 0 |
| Cloud B, C     | 1 |
| Cloud A, B     | 2 |

Cloud A

Cloud B

Cloud C
Cloud A

Cloud B

Cloud C

App Provider

Recommender

Goal & Insight

Ranking List

<table>
<thead>
<tr>
<th>Deployment</th>
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<tbody>
<tr>
<td>Cloud A, C</td>
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<tr>
<td>Cloud B, C</td>
<td>1</td>
</tr>
<tr>
<td>Cloud A, B</td>
<td>2</td>
</tr>
</tbody>
</table>

Deployment

Cloud A, C | 0
Cloud B, C | 1
Cloud A, B | 2
Road-Map

- Motivations
- Goal & Insight
- iRec System
- Next Steps
Road-Map

- Motivations
- Goal & Insight
- iRec System
- Next Steps
Strawman Solution 1

App Provider

Cloud Provider 1

Recommendation

Cloud Provider 2

Cloud Provider 3
Strawman Solution 1

Privacy Concern!

Cloud Provider1

Cloud Provider2

Cloud Provider3
Strawman Solution 2

- App Provider
- Trusted Third Party
- Cloud Provider 1
- Cloud Provider 2
- Cloud Provider 3
Strawman Solution 2

It is hard to find!

Cloud Provider 1

Cloud Provider 2

Cloud Provider 3
Strawman Solution 3

[App Provider] → [Secure Multiparty Computation] → [Cloud Provider1] → [Cloud Provider2] → [Cloud Provider3]

[Xiao et al, CCSW’13]
Strawman Solution 3

SMPC is difficult to scale!

[Cheng et al, CCSW’13]

Cloud Provider1

Cloud Provider2

Cloud Provider3
Our Approach - iRec

- The first cloud independence recommender sys:
  - achieving our goal
  - preserving privacy of each cloud provider
  - practical
Our Approach - iRec

- The first cloud independence recommender sys:
  - achieving our goal
  - preserving privacy of each cloud provider
  - practical

Preliminary background: PSI-CA
Preliminary: PSI-CA

- Private set-intersection cardinality proposed by [Freedman et al, EuroCrypt’04].
- Allows $k$ parties to compute the # of overlapping elements without learning other information.
Preliminary: PSI-CA

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Preliminary: PSI-CA

- Private set-intersection cardinality proposed by [Freedman et al, EuroCrypt’04].
- Allows $k$ parties to compute the # of overlapping elements without learning other information.

But I do not know which element is overlapping.
Alice and Bob has set A and B respectively and Alice wants to jointly compute $|A \cap B|$.

• Alice makes a polynomial $P$ whose roots are the elements of data set A.
• Alice encrypts the coefficients of $P$ and sends them to Bob. Note that Alice sends homomorphic encryptions of the coefficients to Bob.
• Bob evaluates $P(B_i)$ for each element in data set B.
• Bob returns the encrypted evaluations to Alice.
• Alice decrypts it and counts the number of zeroes.
Alice and Bob has set A and B respectively and Alice wants to jointly compute |A ∩ B|.

Alice makes a polynomial P whose roots are the elements of data set A.

Bob evaluates P(B_i) for each element in data set B.

Bob returns the encrypted evaluations to Alice.

Alice decrypts it and counts the number of zeroes.

Preliminary: PSI-CA

P = (X-12)(X-5)(X-4)
= x^3 - 21x^2 + 128x - 240

Data Set A

12
5
4

Data Set B

1
4
6
2

Alice

Bob
Alice and Bob has set A and B respectively and Alice wants to jointly compute $|A \cap B|$.

- Alice makes a polynomial $P$ whose roots are the elements of data set A.
- Alice encrypts the coefficients of $P$ and sends them to Bob. Note that Alice sends homomorphic encryptions of the coefficients to Bob.

$$P = (x-12)(x-5)(x-4) = x^3 - 21x^2 + 128x - 240$$

$\{E(1), E(-21), E(128), E(-240)\}$
Alice and Bob has set A and B respectively and Alice wants to jointly compute $|A \cap B|$.

- Alice makes a polynomial $P$ whose roots are the elements of data set A.
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- Bob evaluates $P(B_i)$ for each element in data set B.

Preliminary: PSI-CA

\[
P = (X-12)(X-5)(X-4) = x^3 - 21x^2 + 128x - 240
\]

\[
\{E(1), E(-21), E(128), E(-240)\}
\]

\[
\{E(P(1))\}
\]

Data Set A

12
5
4

Data Set B

1
4
6
2

Bob
Alice and Bob has set A and B respectively and Alice wants to jointly compute $|A \cap B|$.

Alice makes a polynomial $P$ whose roots are the elements of data set A.

Alice encrypts the coefficients of $P$ and sends them to Bob. Note that Alice sends homomorphic encryptions of the coefficients to Bob.

Bob evaluates $P(B_i)$ for each element in data set B.

$P = (X-12)(X-5)(X-4) = x^3-21x^2+128x-240$

$\{E(1), E(-21), E(128), E(-240)\}$

$\{E(P(1)), E(P(4))\}$
Alice and Bob have set $A$ and $B$ respectively and Alice wants to jointly compute $|A \cap B|$.

Alice makes a polynomial $P$ whose roots are the elements of data set $A$.

Alice encrypts the coefficients of $P$ and sends them to Bob. Note that Alice sends homomorphic encryptions of the coefficients to Bob.

Bob evaluates $P(B_i)$ for each element in data set $B$.

\[
P = (X-12)(X-5)(X-4) = x^3 - 21x^2 + 128x - 240
\]

Alice sends to Bob:

\[
\{E(1), E(-21), E(128), E(-240)\}
\]

Bob returns:

\[
\{E(P(1)), E(P(4)), E(P(6)), E(P(2))\}
\]
• Alice and Bob has set A and B respectively and Alice wants to jointly compute |A ∩ B|.
• Alice makes a polynomial P whose roots are the elements of data set A.
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Alice and Bob have set A and B respectively and Alice wants to jointly compute \(|A \cap B|\).

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Bob evaluates \(P(B_i)\) for each element in data set B.

Bob returns the encrypted evaluations to Alice.

Alice decrypts it and counts the number of zeroes.

---

**Data Set A**

\[
P = (X-12)(X-5)(X-4) = x^3 - 21x^2 + 128x - 240
\]

\([-132, 0, -12, -60]\)
Alice and Bob have set A and B respectively and Alice wants to jointly compute |A \cap B|.

Alice makes a polynomial P whose roots are the elements of data set A.

Alice encrypts the coefficients of P and sends them to Bob. Note that Alice sends homomorphic encryptions of the coefficients to Bob.

Bob evaluates P(Bi) for each element in data set B.

Bob returns the encrypted evaluations to Alice.

Alice decrypts it and counts the number of zeroes.

\[
P = (X-12)(X-5)(X-4) = x^3 - 21x^2 + 128x - 240
\]

\{ -132, 0, -12, -60 \}

Preliminary: PSI-CA

Result is: 1
Preliminary: PSI-CA
Our Approach - iRec

App Provider

Cloud A

Cloud B

Cloud C

ISP A

Power A

Power B

ISP B

Power C
Our Approach - iRec

Select two clouds for redundancy: A&B? B&C? or A&C?

App Provider

iRec
Step 1

App Provider

iRec

Cloud A

Cloud B

Cloud C

ISP A

Power A

Power B

ISP B

Power C
Step 2

App Provider

iRec

Cloud A

Cloud B

Cloud C

ISP A

Power A

Power B

ISP B

Power C
Step 3

App Provider

Cloud A

ISP A
Power A
Power B

Power A

Cloud B

ISP B
Power A
Power B

Power B

Cloud C

ISP B
Power C

Power C
Step 3

App Provider

Cloud A

ISP A
Power A
Power B

PSI-CA

Cloud B

ISP B
Power A
Power B

PSI-CA

Cloud C

ISP B
Power C

ISP A
Power A

Power B

ISP B
Power C

Power C
Step 5

| Deployment | |n| |
|------------|----------------|
| Cloud A, C | 0 |
| Cloud B, C | 1 |
| Cloud A, B | 2 |

App Provider

Recommender

Cloud A

Cloud B

Cloud C

ISP A

Power A

Power B

ISP B

Power C
Step 5

App Provider

Recommend

Cloud A, C | 0
Cloud B, C | 1
Cloud A, B | 2

Deployment

ISP A
Power B
ISP B
Power C
An Improvement Version

• Different infrastructure components play different roles in the clouds
An Improvement Version

• Different infrastructure components play different roles in the clouds

• Power source might be much more likely to fail than ISPs
An Improvement Version

• Different infrastructure components play different roles in the clouds
• Power source might be much more likely to fail than ISPs

• We propose an improvement version
An Improvement Version

• Different infrastructure components play different roles in the clouds

• Power source might be much more likely to fail than ISPs

• We propose an improvement version
  - Using Weighted PSI-CA (W-PSI-CA) to instead of PSI-CA in Step3
  - No other improvement
Recall: Step 3

App Provider

Cloud A

PSI-CA

ISP A
Power A
Power B

Cloud B

PSI-CA

ISP B
Power A
Power B

Cloud C

ISP B
Power C

iRec

ISP A
Power A

Power B

ISP B
Power B

Power C
Recall: Step 3

Result is 2
Using W-PSI-CA
Using W-PSI-CA
Using W-PSI-CA
Using W-PSI-CA

Weights

<table>
<thead>
<tr>
<th>ISP A</th>
<th>1</th>
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<tbody>
<tr>
<td>Power A</td>
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</tr>
<tr>
<td>Power B</td>
<td>2</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>ISP B</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power A</td>
<td>2</td>
</tr>
<tr>
<td>Power B</td>
<td>2</td>
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</table>
Using W-PSI-CA
Using W-PSI-CA
Using W-PSI-CA
Using W-PSI-CA

Result is 4

Cloud A

<table>
<thead>
<tr>
<th>DSI</th>
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<tbody>
<tr>
<td>ISP A</td>
</tr>
<tr>
<td>Power A</td>
</tr>
<tr>
<td>Power A</td>
</tr>
<tr>
<td>Power B</td>
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<tr>
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</table>

- PSI-CA

Cloud B

<table>
<thead>
<tr>
<th>DSI</th>
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<tbody>
<tr>
<td>ISP B</td>
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<tr>
<td>Power B</td>
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</table>

ISP A

Power A

ISP B

Power B
Case Study
Step 1

Select two clouds for redundancy: A&B? B&C? or A&C?
Step 1

App Provider → iRec

Cloud A → Cloud B → Cloud C

ISP A → Power A → Power B → ISP B

ISP C → Power C
Step 2

App Provider

Cloud A

Cloud B

Cloud C

iRec

Weights

Weights

Weights

ISP A

Power A

Power B

ISP B

Power C
Step 3 & 4 with W-PSI-CA

| Deployment | |n| |
|------------|-----|
| Cloud A, C | 0   |
| Cloud B, C | 1   |
| Cloud A, B | 2   |

ISP A | 3
| Power A | 1
| Power B | 1

ISP B | 3
| Power A | 1
| Power B | 1

ISP B | 3
| Power C | 1

Cloud A

Cloud B

Cloud C
Step 3 & 4 with W-PSI-CA

| Deployment | |n|
|------------|---|
| Cloud A, C | 0 |
| Cloud B, C | 1 |
| Cloud A, B | 2 |

App Provider

Cloud A

<table>
<thead>
<tr>
<th>ISP A</th>
<th>Power A</th>
<th>Power B</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
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<td>1</td>
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</table>

Cloud B

<table>
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<th>ISP B</th>
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Cloud C

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ISP A

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Power A

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Power B

<table>
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Power C

<table>
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<th>Power A</th>
<th>Power B</th>
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</thead>
<tbody>
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<td>1</td>
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ISP B

<table>
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ISP C

<table>
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<th>Power B</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Step 3 & 4 with W-PSI-CA

| Deployment | |n| |
|------------|---|---|
| Cloud A, C | 0 |
| Cloud B, C | 1 |
| Cloud A, B | 2 |

App Provider

ISP A
ISP A
ISP A
Power A
Power B

Cloud A

ISP B
ISP B
ISP B
Power A
Power B

Cloud B

ISP B
ISP B
ISP B
Power C

Cloud C

ISP A
Power A

Power B

ISP B
Power B

Power C

iRec
Step 3 & 4 with W-PSI-CA

| Deployment  | |n| |
|-------------|---|---|
| Cloud A, C  | 0 |
| Cloud B, C  | 1 |
| Cloud A, B  | 2 |

App Provider


Cloud B: ISP A

Cloud C: ISP B, ISP B, Power C

iRec

PSI-CA
Step 3 & 4 with W-PSI-CA

| Deployment   | $|n|$
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Cloud A, C</td>
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</tr>
<tr>
<td>Cloud B, C</td>
<td>1</td>
</tr>
<tr>
<td>Cloud A, B</td>
<td>2</td>
</tr>
</tbody>
</table>

App Provider

Cloud A

ISP A
ISP A
ISP A
Power A
Power B

Cloud B

Power B

Cloud C

ISP B
ISP B
ISP B
Power C

iRec

ISP A
Power A

Power B

ISP B

Power C

PSI-CA
Step 3 & 4 with W-PSI-CA

| Deployment | |n| |
|------------|--|--|
| Cloud A, C | 0 |
| Cloud B, C | 1 |
| Cloud A, B | 2 |

App Provider

Cloud A
- ISP A
- ISP A
- ISP A
- Power A
- Power B

Cloud B
- ISP B
- ISP B
- ISP B
- Power A
- Power B

Cloud C
- ISP B
- ISP B
- ISP B
- Power C

iRec

PSI-CA

ISP A
- Power A

Power B

ISP B
- Power B

Power C
Step 3 & 4 with W-PSI-CA

| Deployment     | |n| |
|----------------|---|---|
| Cloud A, C     | 0 |
| Cloud B, C     | 3 |
| Cloud A, B     | 2 |

App Provider

Cloud A

ISP A
ISP A
ISP A
Power A
Power B

Cloud B

ISP B
ISP B
ISP B
Power A
Power B

Cloud C

ISP B
ISP B
ISP B
Power C

iRec

PSI-CA

ISP A
Power A

Power B

ISP B

Power C

ISP A
Power A

Power B

ISP B

Power C
Step 3 & 4 with W-PSI-CA

| Deployment   | |n| |
|--------------|---|---|
| Cloud A, C   | 0 |   |
| Cloud B, C   | 3 |   |
| Cloud A, B   | 2 |   |

App Provider

Cloud A

ISP A
ISP A
ISP A
Power A
Power B

Cloud B

ISP B
ISP B
ISP B
Power A
Power B

Cloud C

ISP B
ISP B
ISP B
Power C

iRec

ISP A
Power A

Power B

ISP B

Power C
Step 3 & 4 with W-PSI-CA

![Diagram showing the interaction between App Provider, iRec, Cloud A, Cloud B, Cloud C, and the involved ISPs and powers.]

| Deployment | |n|
|------------|---|
| Cloud A, C | 0 |
| Cloud B, C | 3 |
| Cloud A, B | 2 |

ISP A, ISP A, ISP A
Power A, Power A

ISP B, ISP B, ISP B
Power A, Power B

ISP B, ISP B, ISP B
Power C
Step 5

App Provider ➠ iRec

| Deployment | |n|
|------------|---|
| Cloud A, C | 0 |
| Cloud B, C | 3 |
| Cloud A, B | 2 |
Step 5

| Deployment     | |n| |
|----------------|---|---|
| Cloud A, C     | 0 |
| Cloud B, C     | 3 |
| Cloud A, B     | 2 |

App Provider

iRec

Cloud A

Cloud B

Cloud C
Step 5

| Deployment     | |n| |
|----------------|---|---|
| Cloud A, C     | 0 |
| Cloud A, B     | 2 |
| Cloud B, C     | 3 |

App Provider → iRec

Cloud A → Cloud B → Cloud C
Step 5

App Provider

| Deployment       | \(|n|\) |
|------------------|-------|
| Cloud A, C       | 0     |
| Cloud A, B       | 2     |
| Cloud B, C       | 3     |

iRec

Cloud A
Cloud B
Cloud C

| Deployment       | \(|n|\) |
|------------------|-------|
| Cloud A, C       | 0     |
| Cloud A, B       | 2     |
| Cloud B, C       | 3     |
Step 5

App Provider

iRec

<table>
<thead>
<tr>
<th>Deployment</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cloud A, C</td>
<td>0</td>
</tr>
<tr>
<td>2. Cloud A, B</td>
<td>2</td>
</tr>
<tr>
<td>3. Cloud B, C</td>
<td>3</td>
</tr>
</tbody>
</table>

Ranking list with W-PSI-CA

<table>
<thead>
<tr>
<th>Deployment</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cloud A, C</td>
<td>0</td>
</tr>
<tr>
<td>2. Cloud B, C</td>
<td>1</td>
</tr>
<tr>
<td>3. Cloud A, B</td>
<td>2</td>
</tr>
</tbody>
</table>

Ranking list with PSI-CA
Road-Map

- Motivations
- Goal & Insight
- iRec System
- Next Steps
Road-Map

• Motivations
• Goal & Insight
• iRec System
• Next Steps
Next Steps

- Can we provide stronger privacy preservation?
Next Steps

• Can we provide stronger privacy preservation?
• Do cloud providers have incentives to join?
Next Steps

• Can we provide stronger privacy preservation?
• Do cloud providers have incentives to join?
• Will the clouds behave honestly?
Next Steps

• Can we provide stronger privacy preservation?
• Do cloud providers have incentives to join?
• Will the clouds behave honestly?
• Can we make iRec more scalable?
• How do we evaluate iRec with realistic cloud dependency datasets?
Thanks!

Questions?