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How to Cope with Information Leakage in The Ubiquitous Environment

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of Personal Data Leakage Incidents and Victims in Japan

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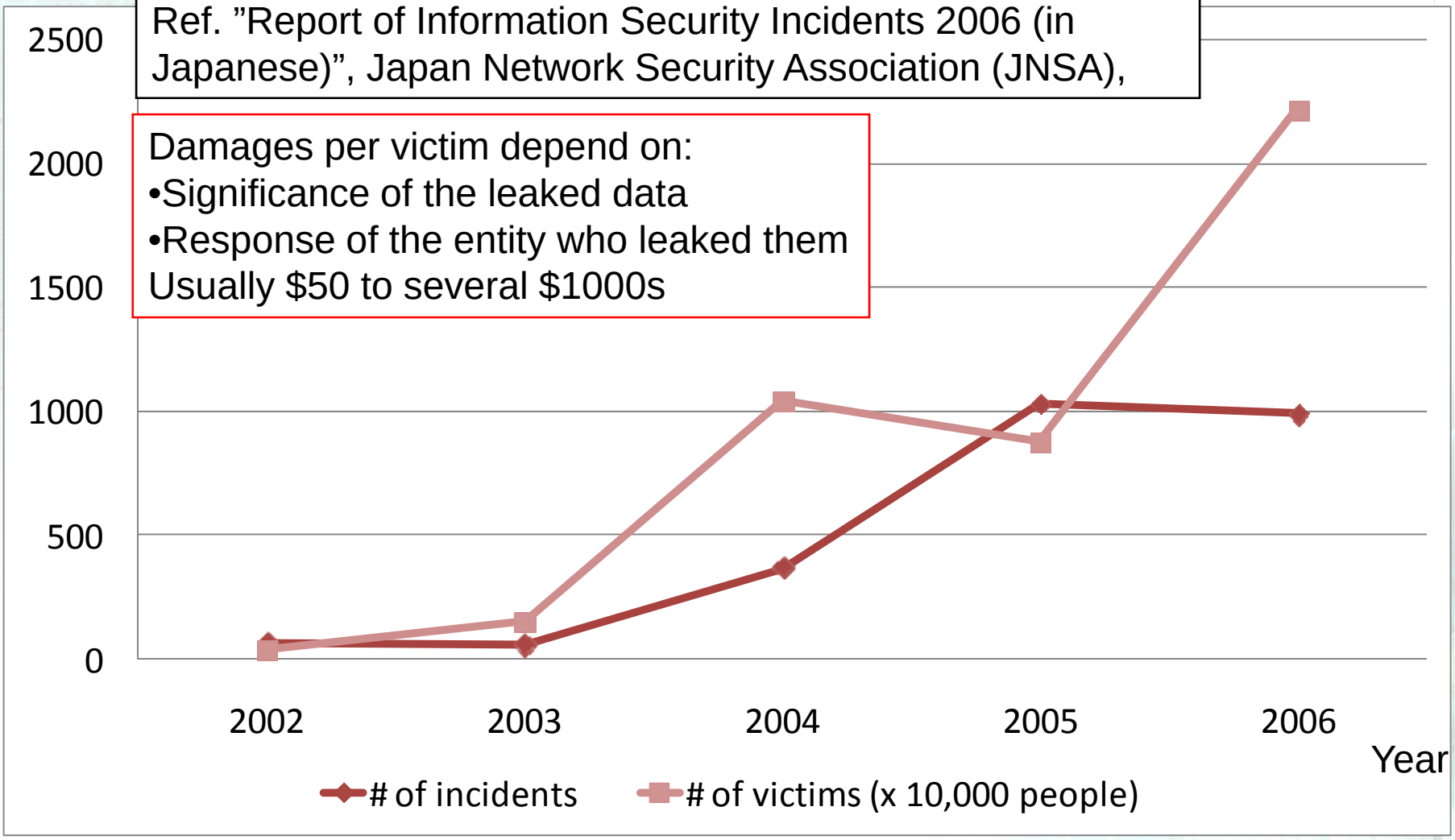
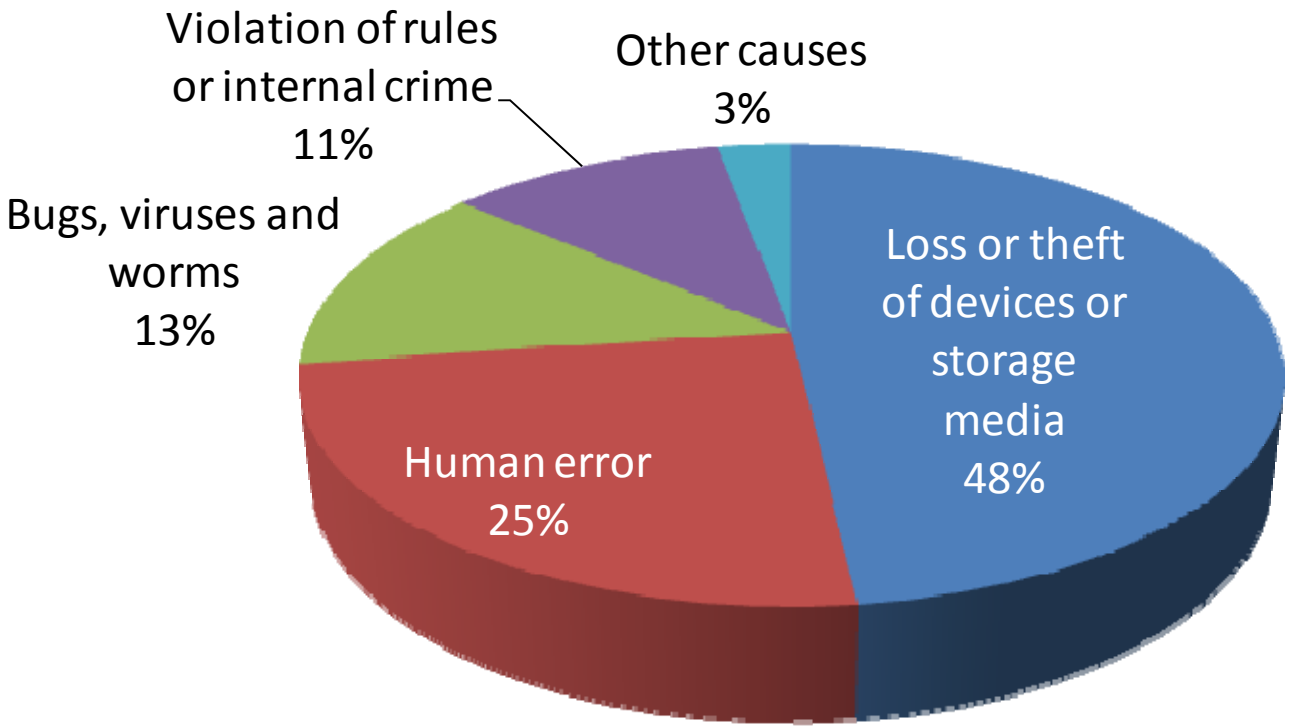
Ref. "Report of Information Security Incidents 2006 (in Japanese)", Japan Network Security Association (JNSA),

Damages per victim depend on:
- Significance of the leaked data
- Response of the entity who leaked them

Usually $50 to several $1000s



Causes of Leaks (Japan 2006)



Ref. ”Report of Information Security Incidents 2006 (in Japanese)”, Japan Network Security Association (JNSA),

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Channels of Leaks (Across the Globe 2006)

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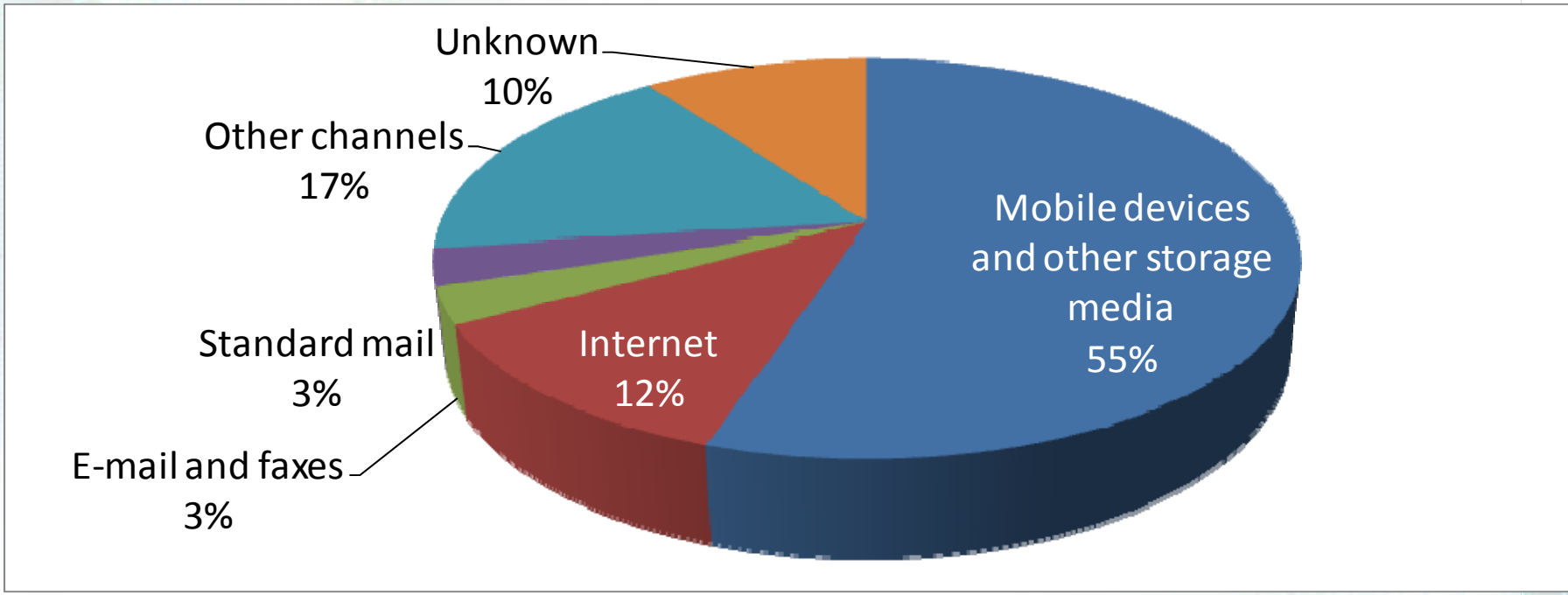

"Global Data Leakage Survey 2006," InfoWatch, http://www.infowatch.com/threats?chapter=162971949&id=207784626

These statistics show

- Protection of mobile devices and storage media is important to resist against information leakage

- Question is how to protect them?
  - One solution must be encryption but the problem is where to store the decryption key

Trivial Solutions

- How about storing it in TRM?
  - It is still hard to realize perfect TRM with low-cost due to side channel attacks, such as DPA
- How about encrypting it with a password?
  - Short passwords can easily be exhaustively searched
  - Long passwords are hard to remember

TRM: Tamper Resistant Module
DPA: Differential Power Analysis

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Scenario I: Two Node Construction (2NC)

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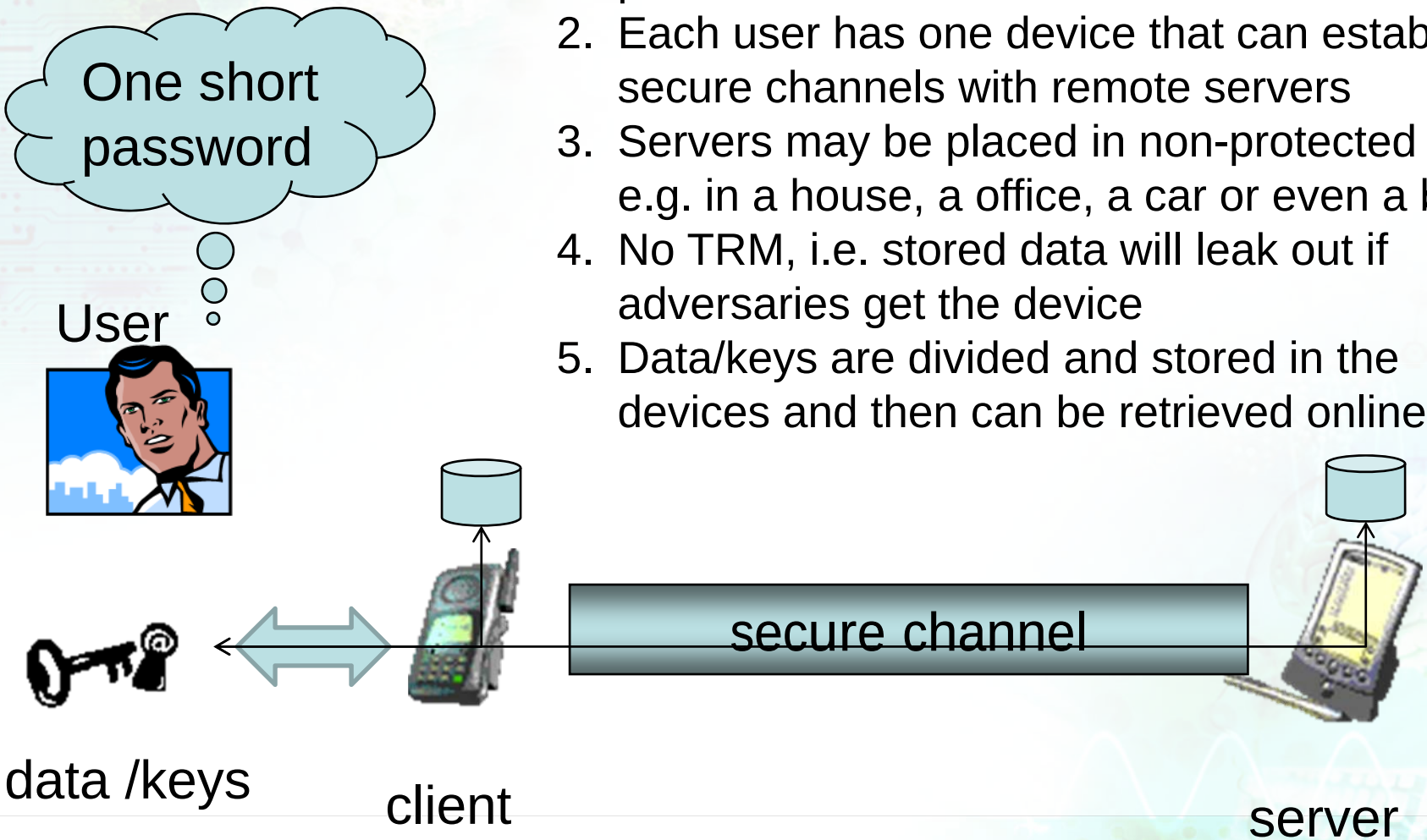
1. Each user remembers only one short password
2. Each user has one device that can establish secure channels with remote servers
3. Servers may be placed in non-protected area, e.g. in a house, a office, a car or even a bag
4. No TRM, i.e. stored data will leak out if adversaries get the device
5. Data/keys are divided and stored in the devices and then can be retrieved online



Problem 2

- While our scenario assumes leakage
- Most of the currently available protocols are vulnerable against information leakage
  - Since they are designed under the assumption that keys to establish secure channels are protected securely and never leak out
- So, once the keys leak out In their protocols,
  - adversaries can obtain the stored data or/and the user's personal password

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Bad Example I (Hashed Password)

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PK

SK

Short password

abduction
abnormal
abolish
absolute
...

h(“abduction”)=?S

h(“abnormal”)=?S

h(“abolish”)=?S

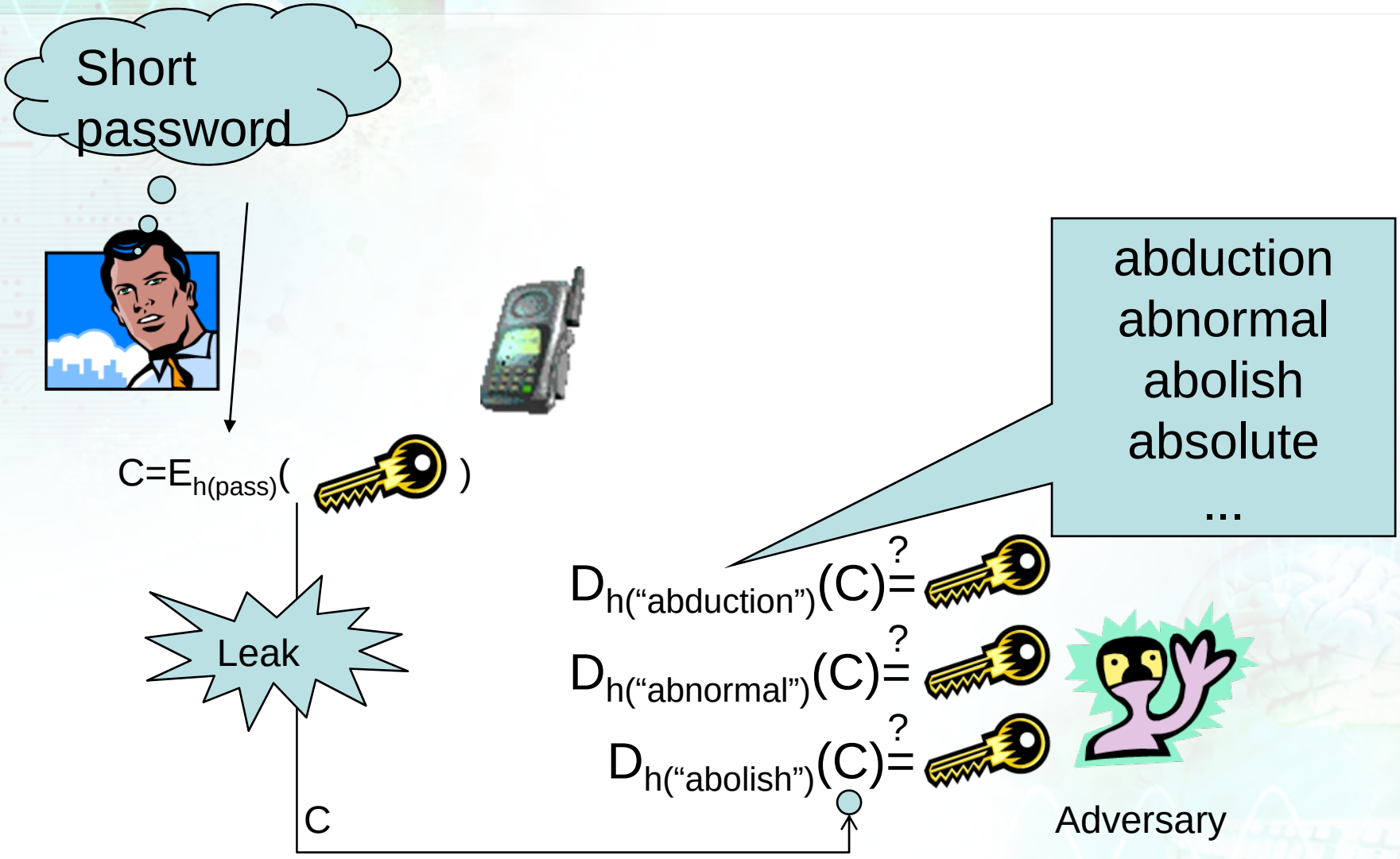
...

h(pass)=S

Leak

S

Bad Example II (PW-Protected-Keys)



Comparison among AKE Protocols

Can adversary obtain data or PW ? ○: No, ×: Yes / Protocols	Eaves dropping	Parallel On-line Attack	Resilience against Leakage			PW to remember
			From client	From server	From both with time difference	
Conventional PW-Only	×	×	○	×	×	Many
PAKE	○	×	○	×	×	Many
PKI（Server Auth.+PW）	○	×	○	×	×	Many
PKI（Server Auth.+PW+OTP）	○	○	○	×	×	Many
KPS+PW	○	○	×	×	×	One
PKI（Mutual Auth.）	○	○	×	○	×	One
LR-AKE（Our proposal）	○	○	○	○	○	One

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LR-AKE (Leakage-Resilient AKE)

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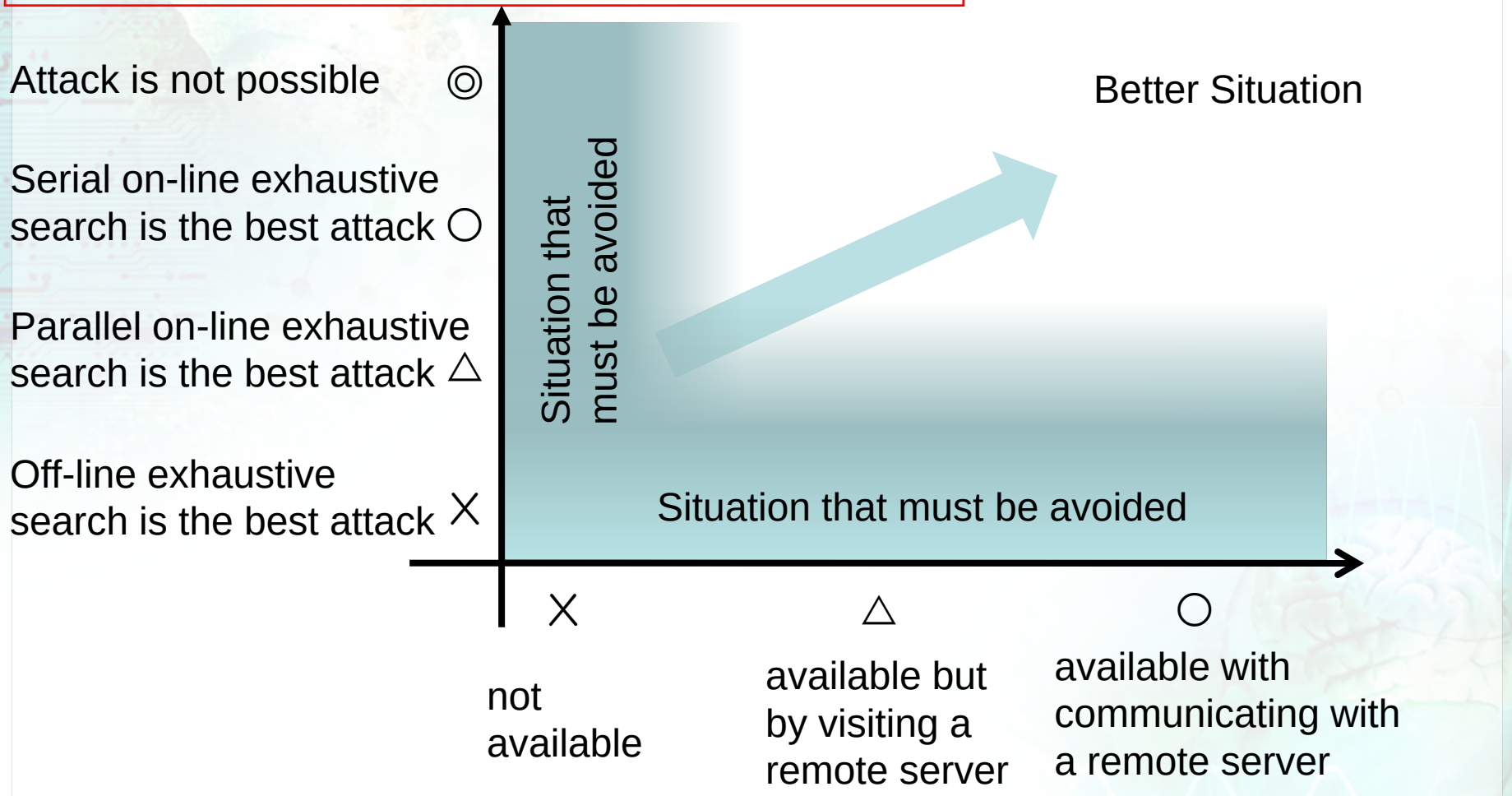
- New class of AKE (Authenticated Key Establishment) protocols
  - designed under the assumption that
    - Keys (more generally stored secrets) may leak out
  - can resist against information-leakage
- They fit with the scenario we consider

[SKI03] S. H. Shin, K. Kobara, and H. Imai, "Leakage-resilient authenticated key establishment protocols," Proc. of ASIACRYPT 2003, LNCS 2894, pp.166-172, 2003
[SKI07] S. H. Shin, K. Kobara, and H. Imai, "An Efficient and Leakage-Resilient RSA-Based Authenticated Key Exchange Protocol with Tight Security Reduction", IEICE Trans. Vol. E90-A, No. 2, pp. 474-490, 2007
[NGSP] "New Generation Security Project," Ministry of Economy, Trade and Industry, 2005-2007

Leakage-Resilience and Availability

Leakage-Resilience of Stored Data or Password



Availability of Stored Data

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On-line Exhaustive Search

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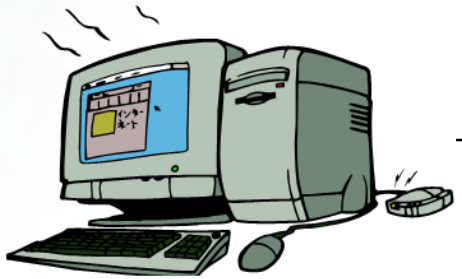
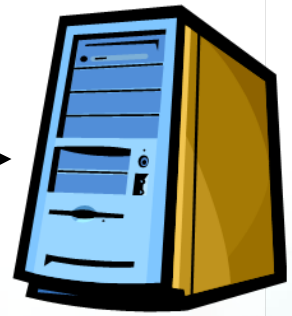
abduction
abnormal
abolish
absolute
...

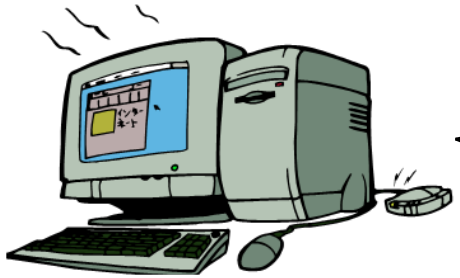
password



Alice, xxxx Alice, xxxx



Serial



Alice, xxxx

Bob, xxxx

Carol, xxxx

Parallel

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Off-line Exhaustive Search

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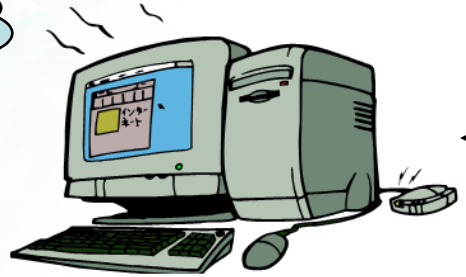
password

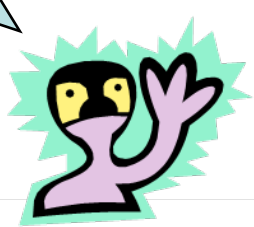


ID	PW
Alice	xxx
Bob	yyy

1. Gets the data for verifying the password
2. Tries password candidates off-line

This can be done with high speed in parallel

abduction
abnormal
abolish
absolute
...



f("abduction") $\stackrel{?}{=}$XXX

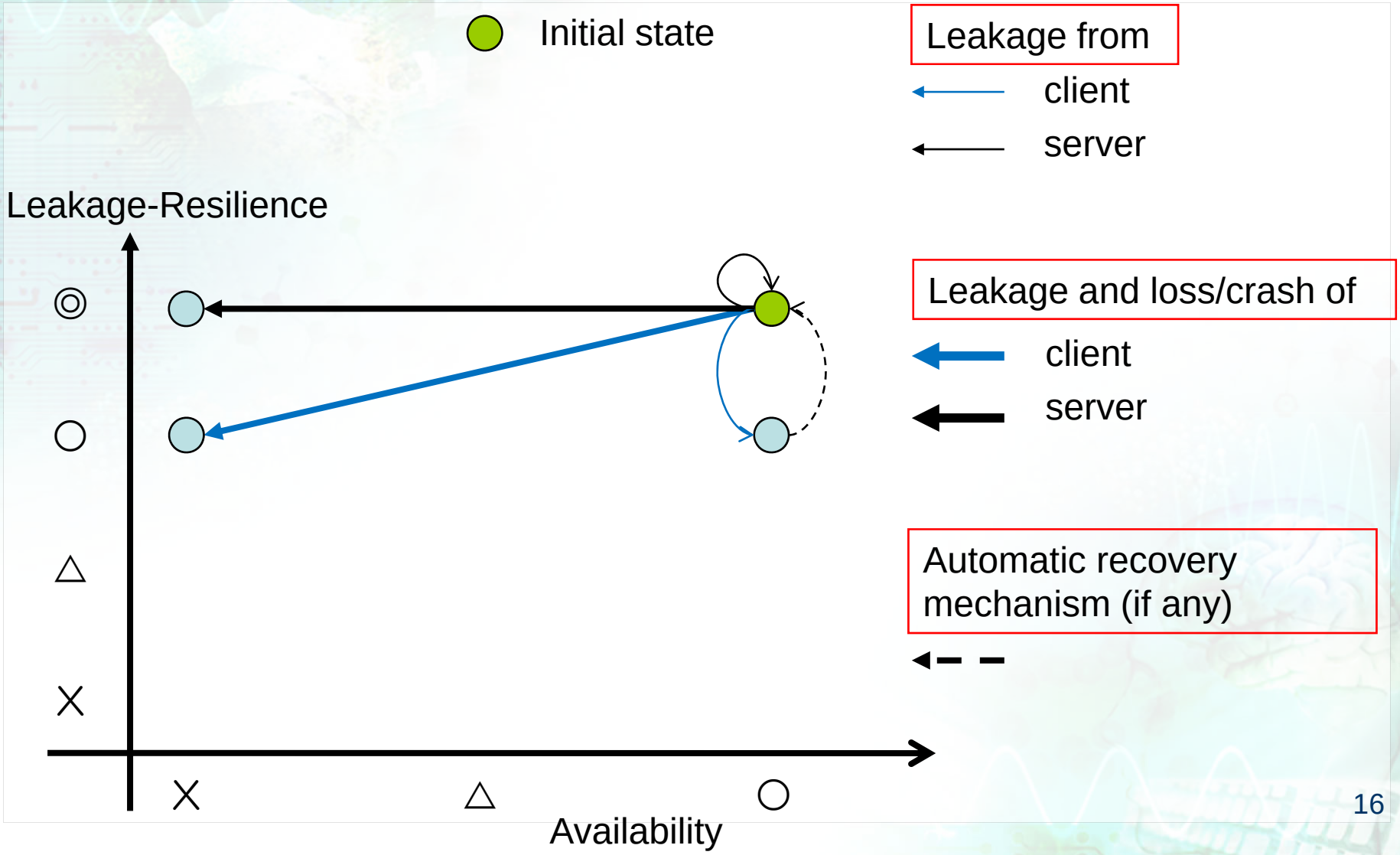
f("abnormal") $\stackrel{?}{=}$XXX

f("abolish") $\stackrel{?}{=}$XXX

...

XXX

Damage against Node Compromise



Conventional PW-Only Protocols in 2NC

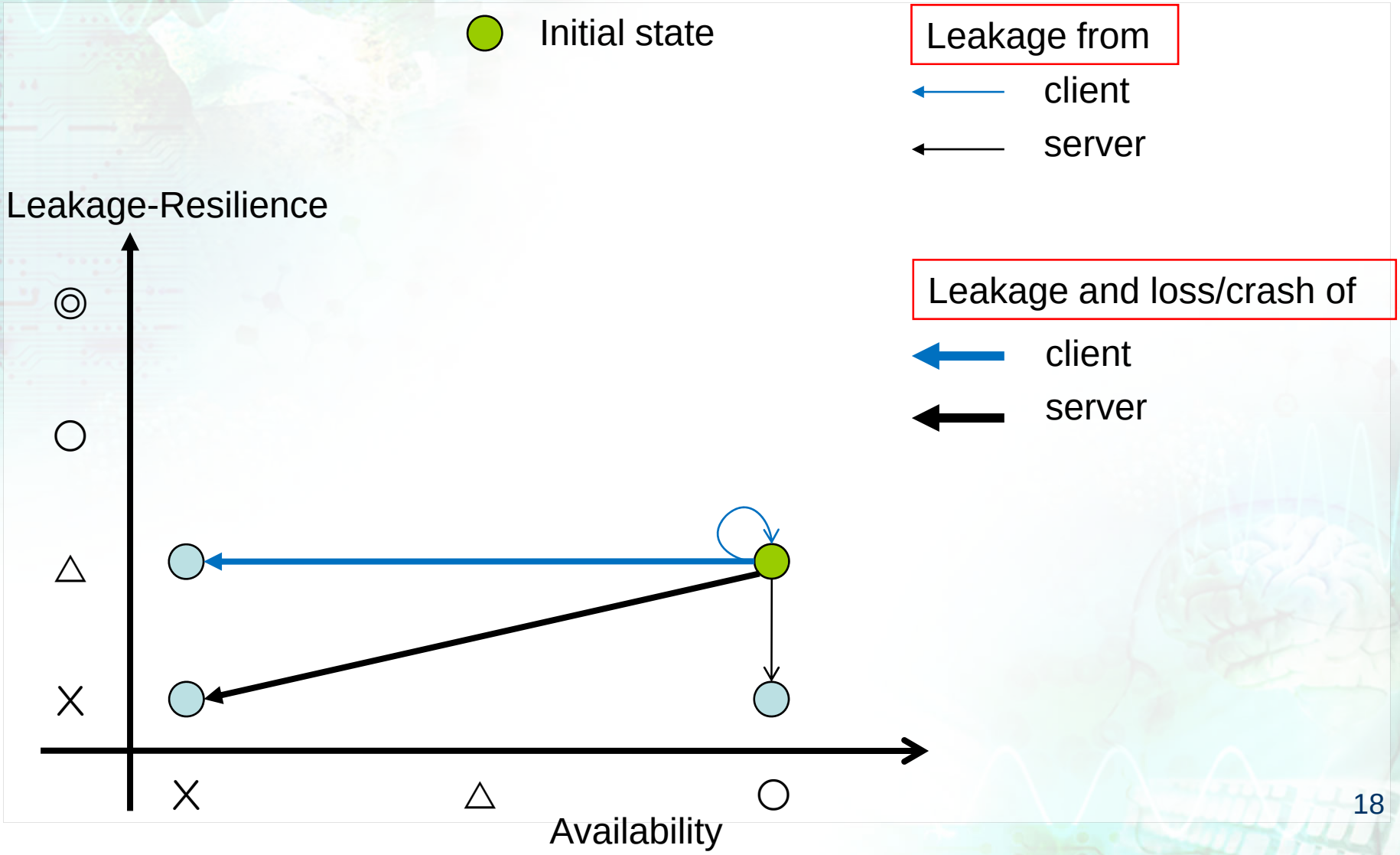
Such as CHAP, IPsec/IKE (PSK), EAP-PSK and so on

Initial state

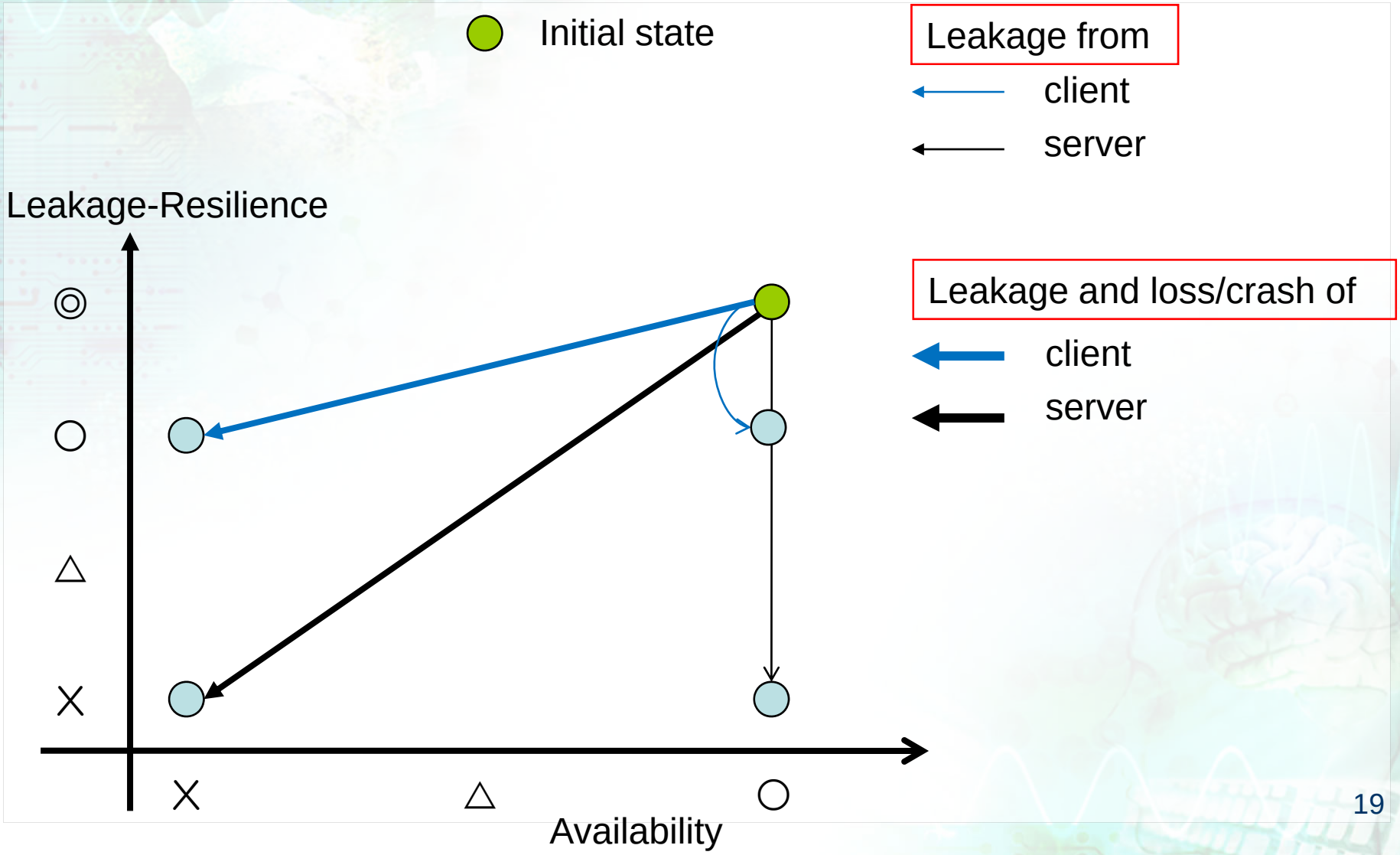
Leakage from
client
server

Leakage and loss/crash of
client
server

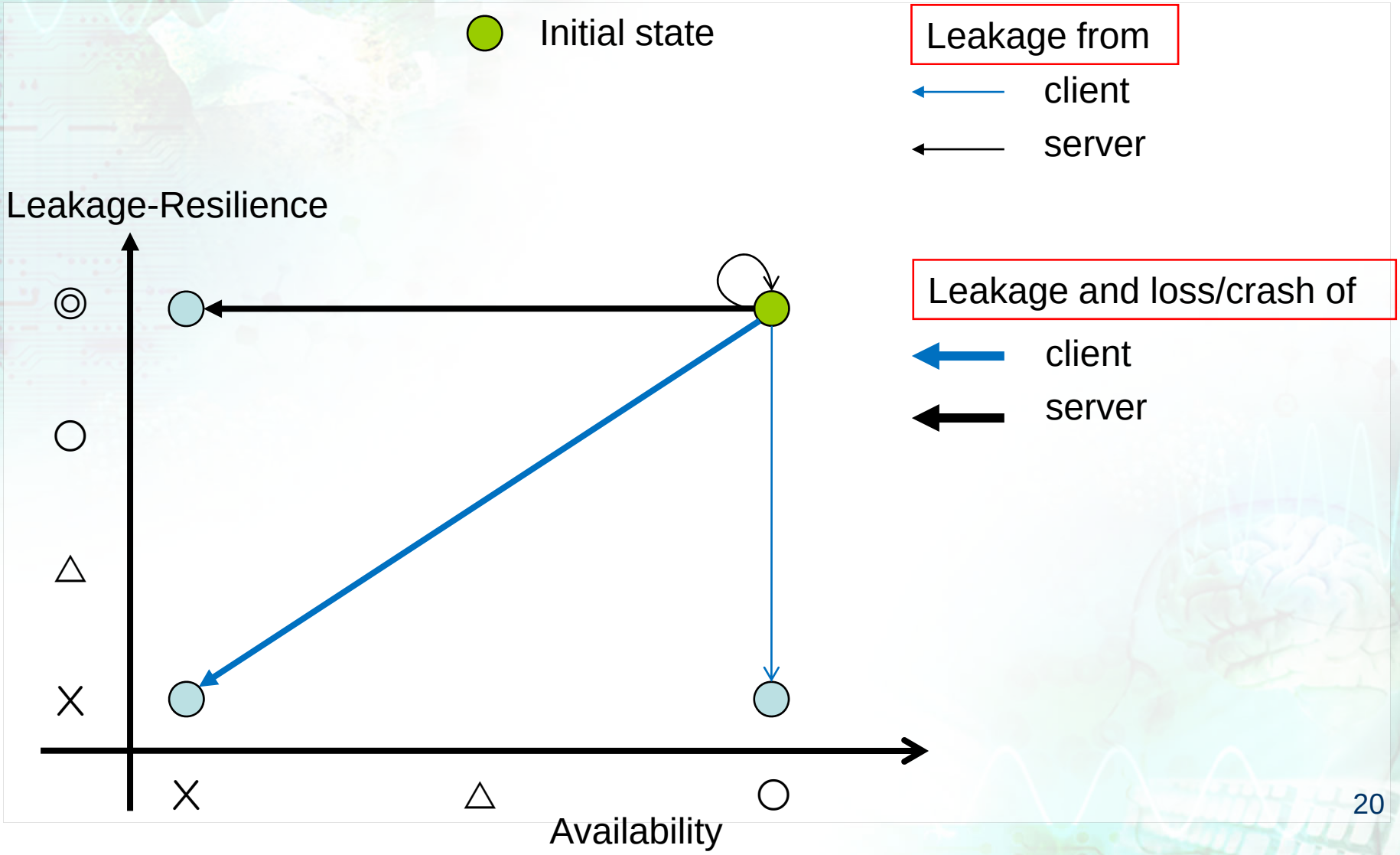
PKI (Server Auth+PW) or PAKE in 2NC



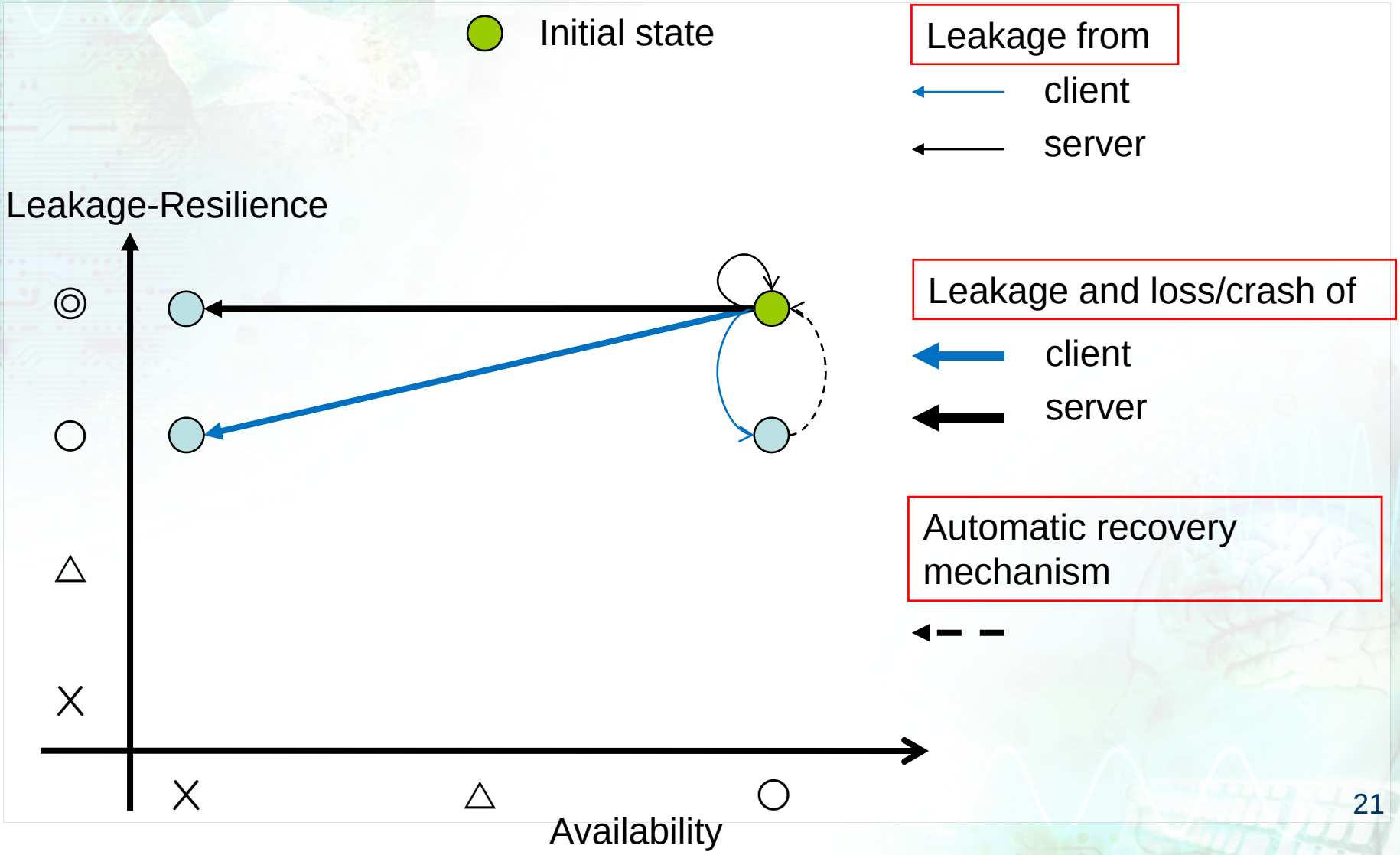
PKI (Server Auth+PW+OTP) in 2NC



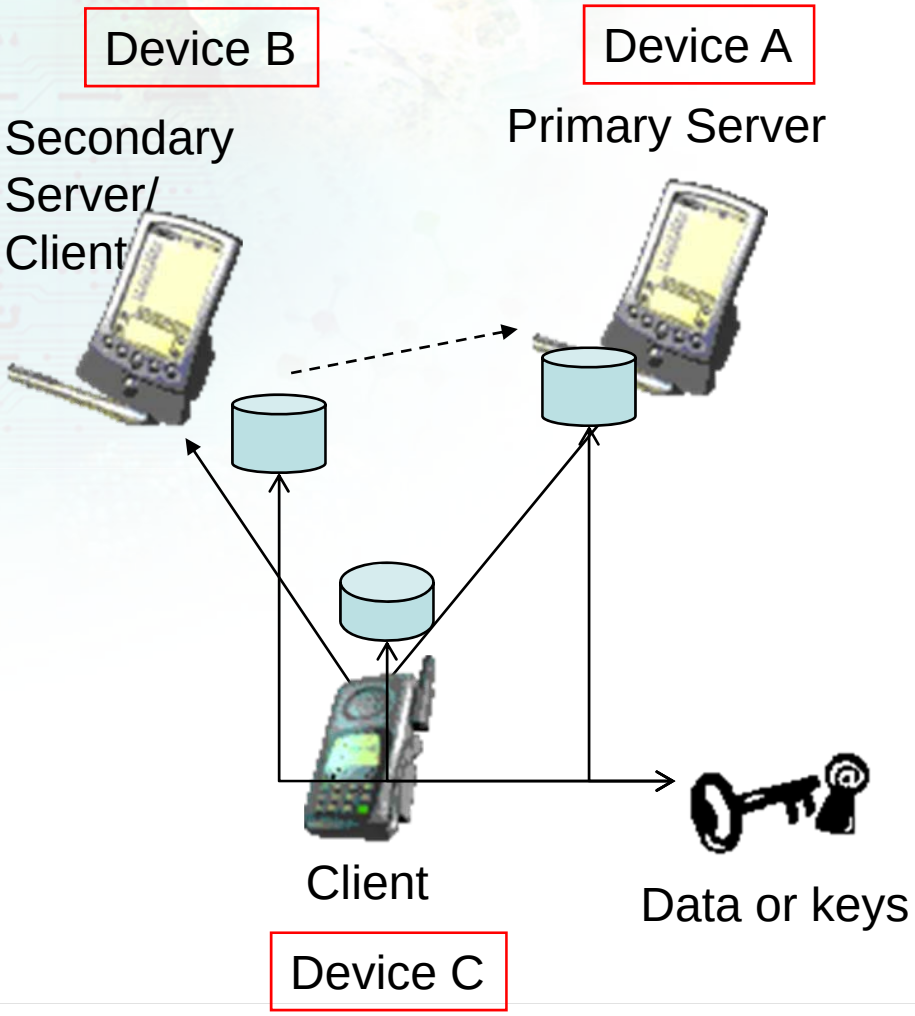
PKI (Mutual Auth) in 2NC



LR-AKE (Single Mode) in 2NC

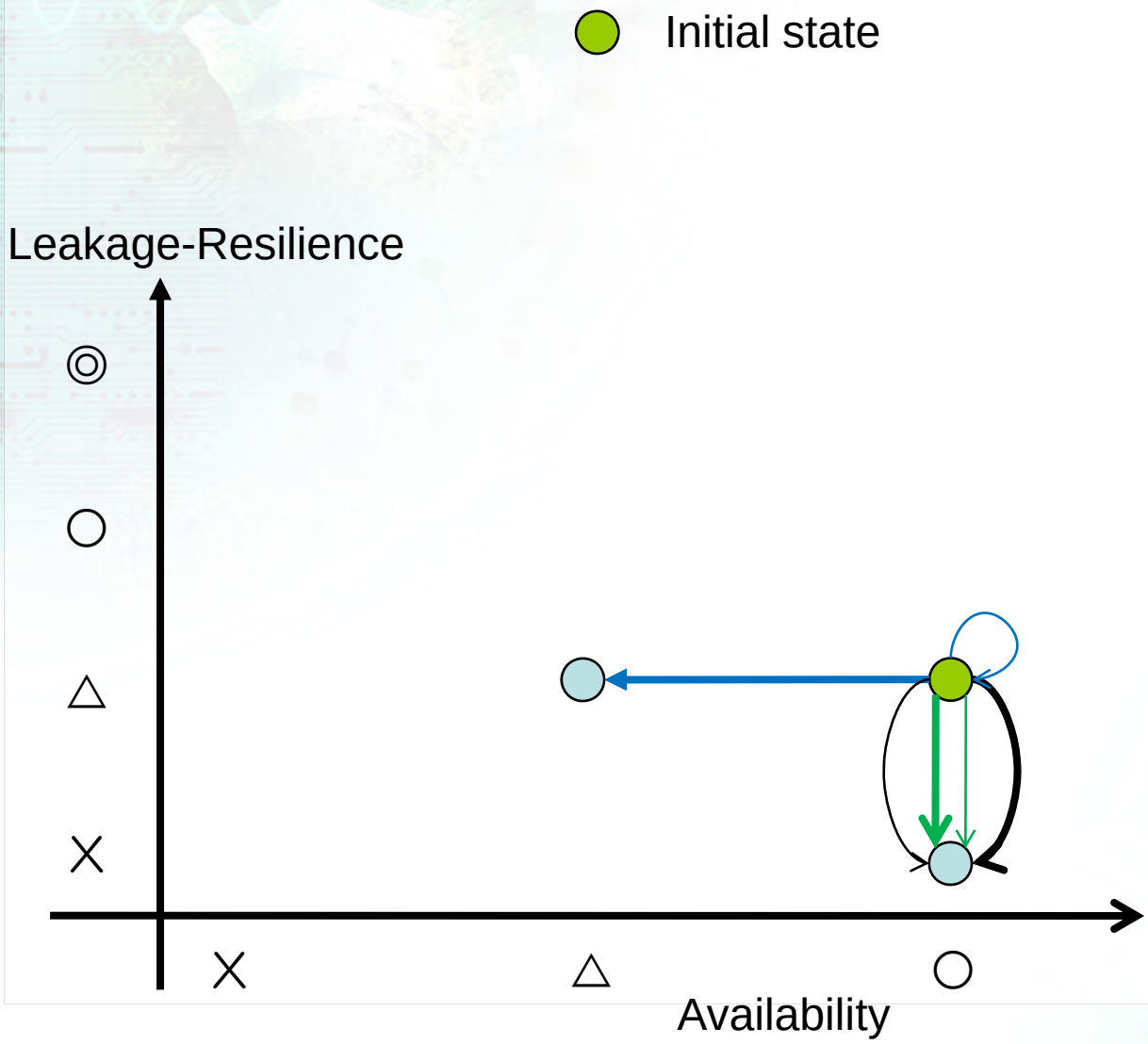


Scenario II : Three Node Construction (3NC [Type A])

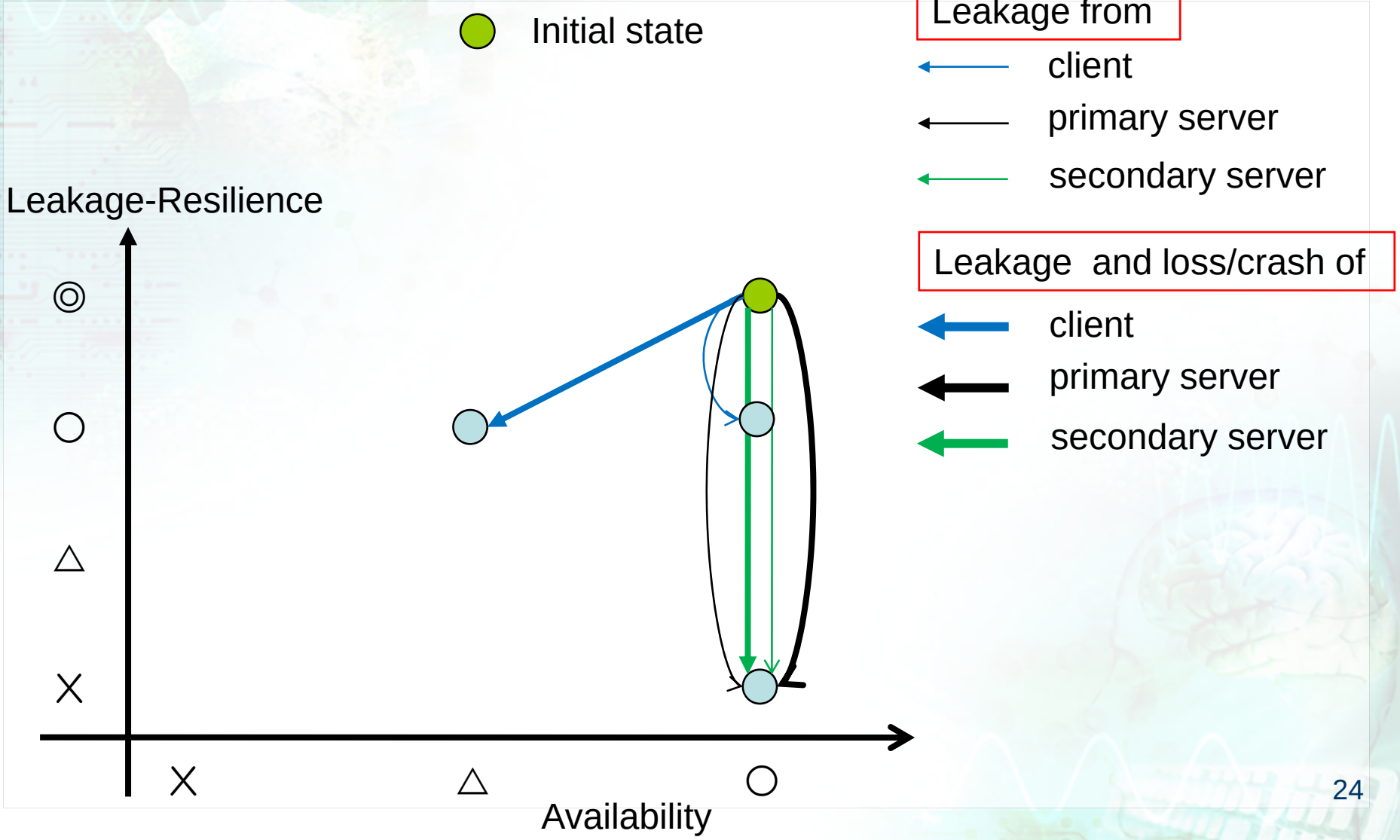


1. A user uses Device C as a client and Devices A and B as primary and secondary servers, respectively
2. When he/she lost Device C, visits at Device B and uses it as a client
3. Data/keys are divided and stored in these devices

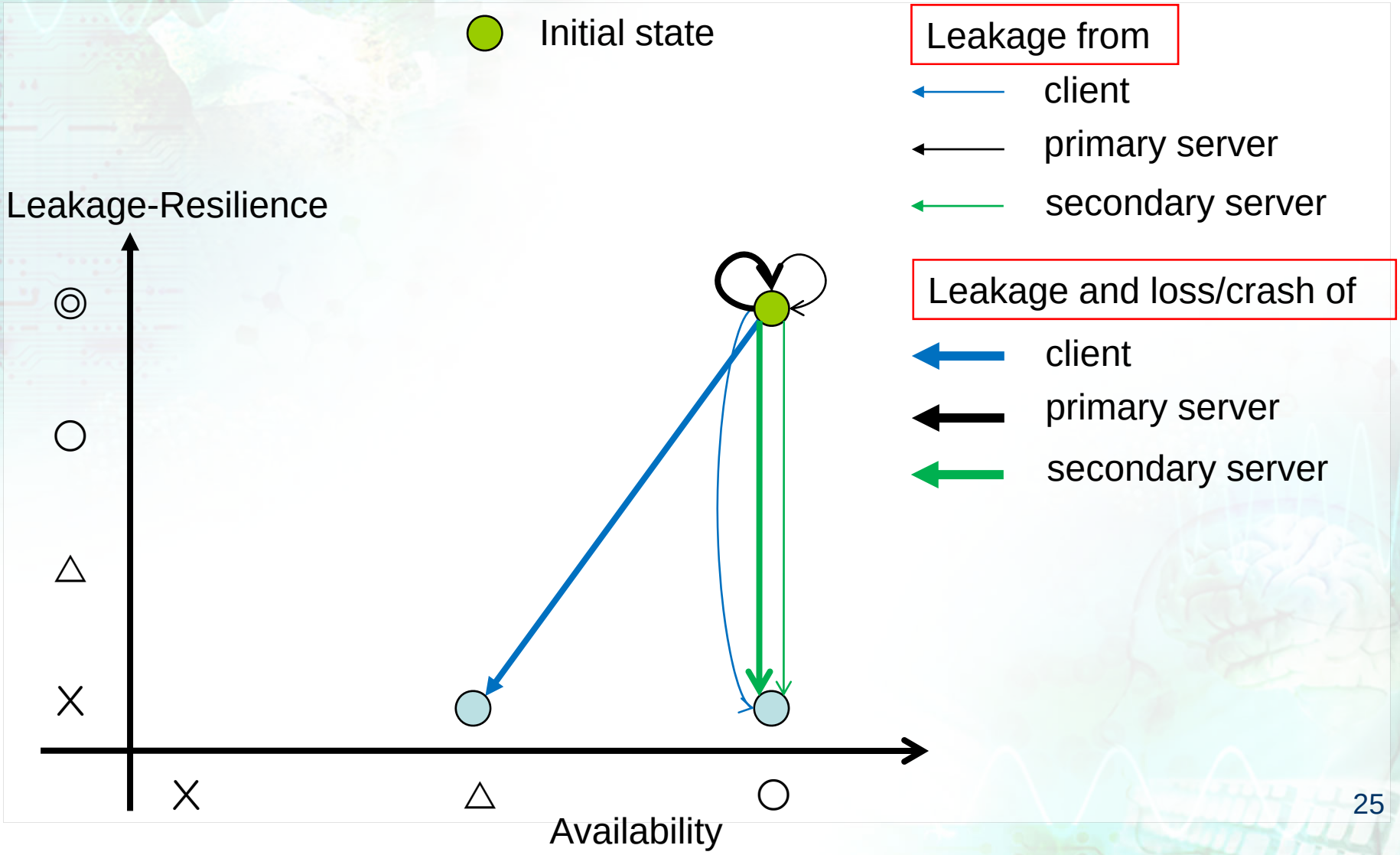
PKI(Server Auth + PW) in 3NC



PKI (Server Auth+PW+OTP) in 2NC



PKI (Mutual-Auth) in 3NC



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LR-AKE (Cluster Mode) in 3NC

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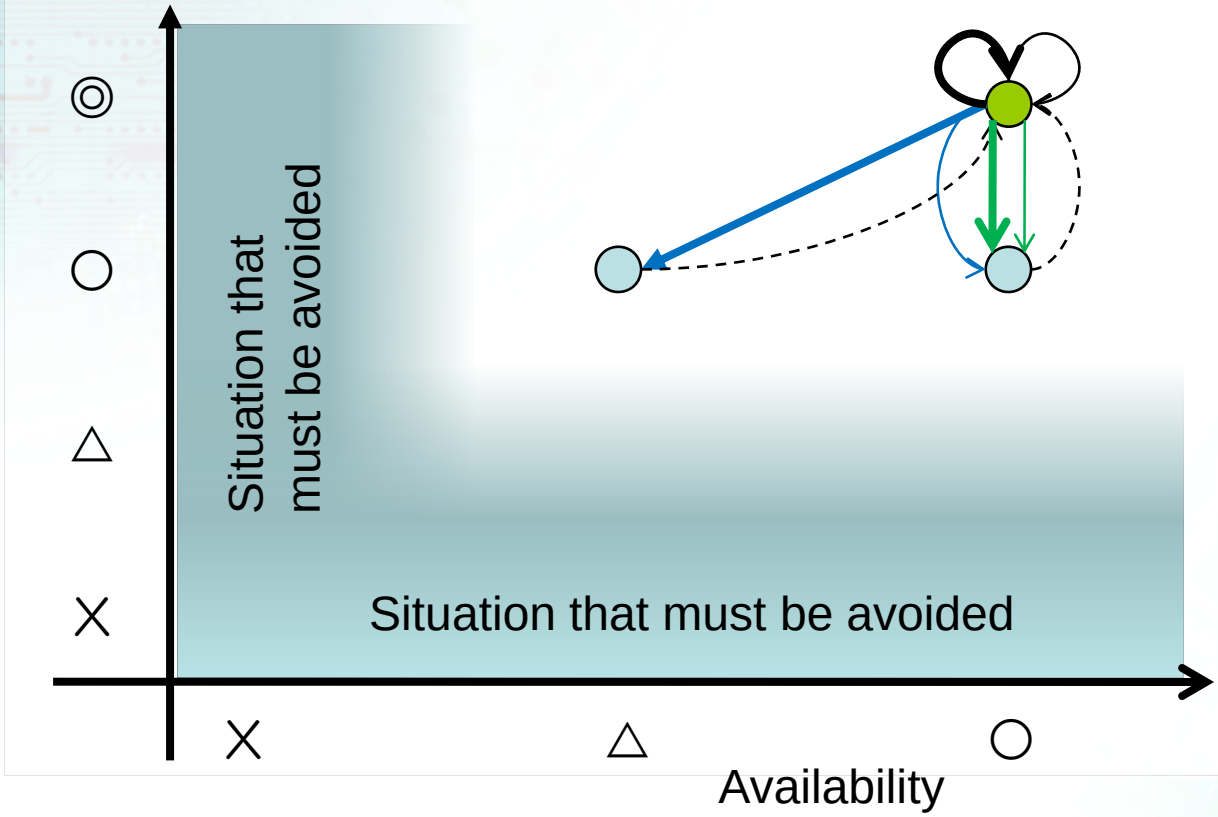
Initial state

Leakage from
- client
- primary server
- secondary server

Leakage and loss/crash of
- client
- primary server
- secondary server

Automatic recovery mechanism



Conclusion

- Leakage of critical information causes serious problems
- Encryption may be a solution, but the problem is where to store the decryption key
- We considered to store it in a distributed network
- And then showed the relationship of leakage resilience and availability
  - 3NC using LR-AKE has the best leakage resilience and availability