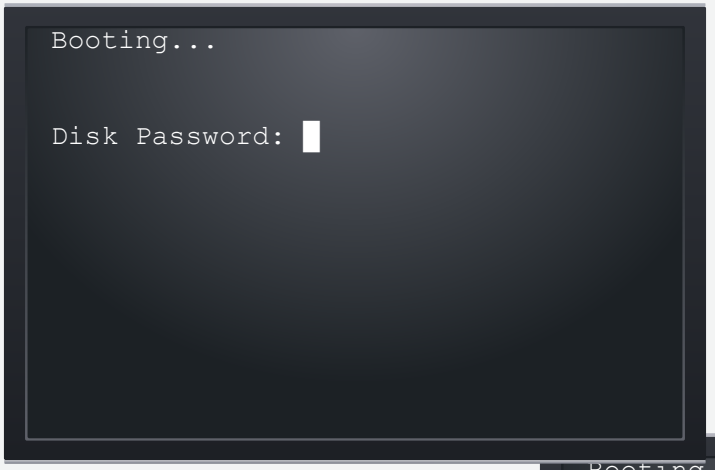
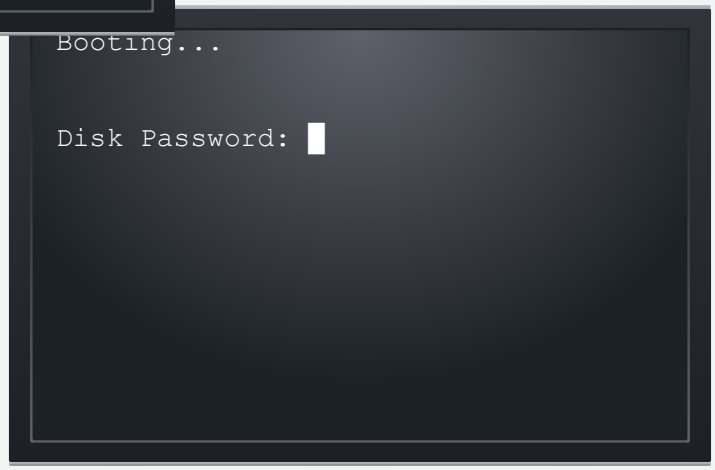
SECURING AUTOMATED DECRYPTION

Thorsten Scherf
Principal Software Maintenance Engineer - Red Hat


Booting...
Disk Password:


Booting...
Disk Password: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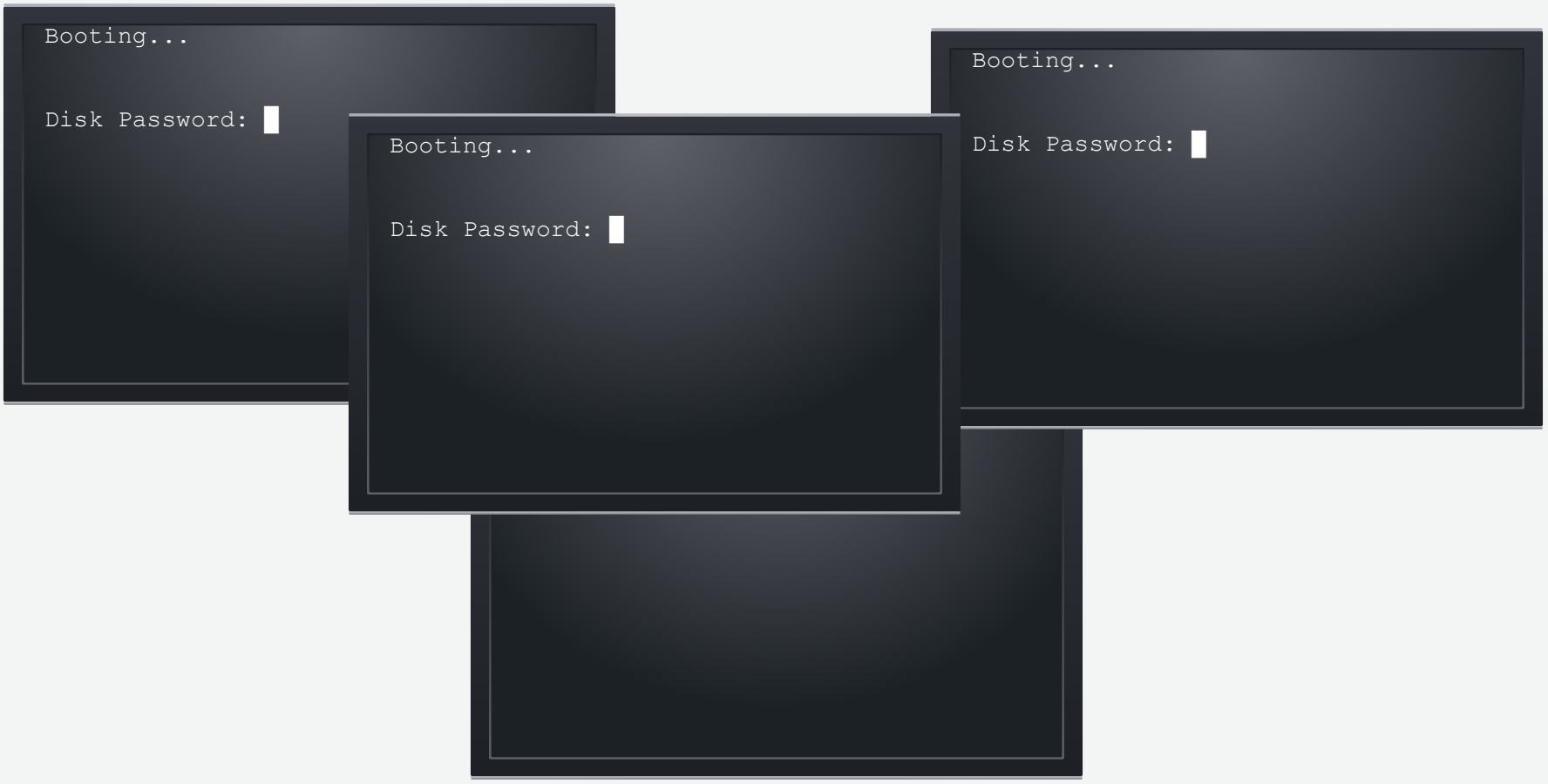
Disk Password:


Booting...
Disk Password:
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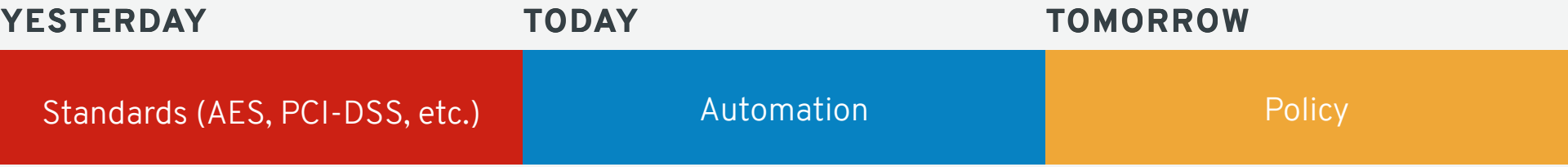
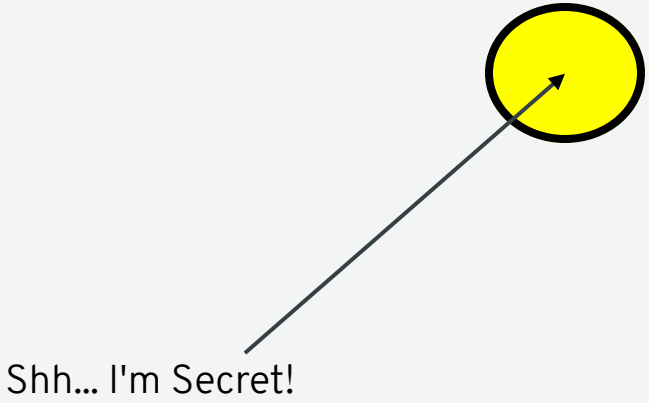
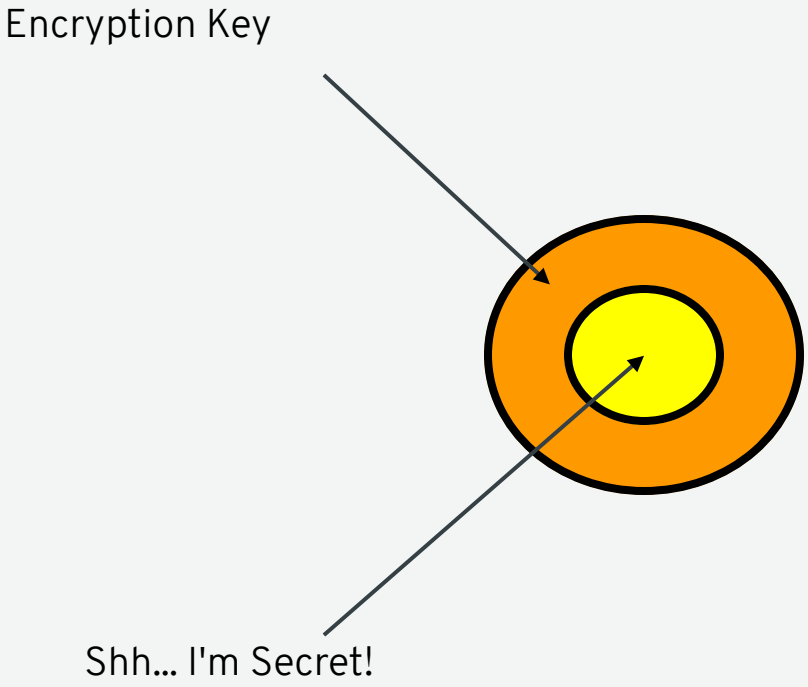
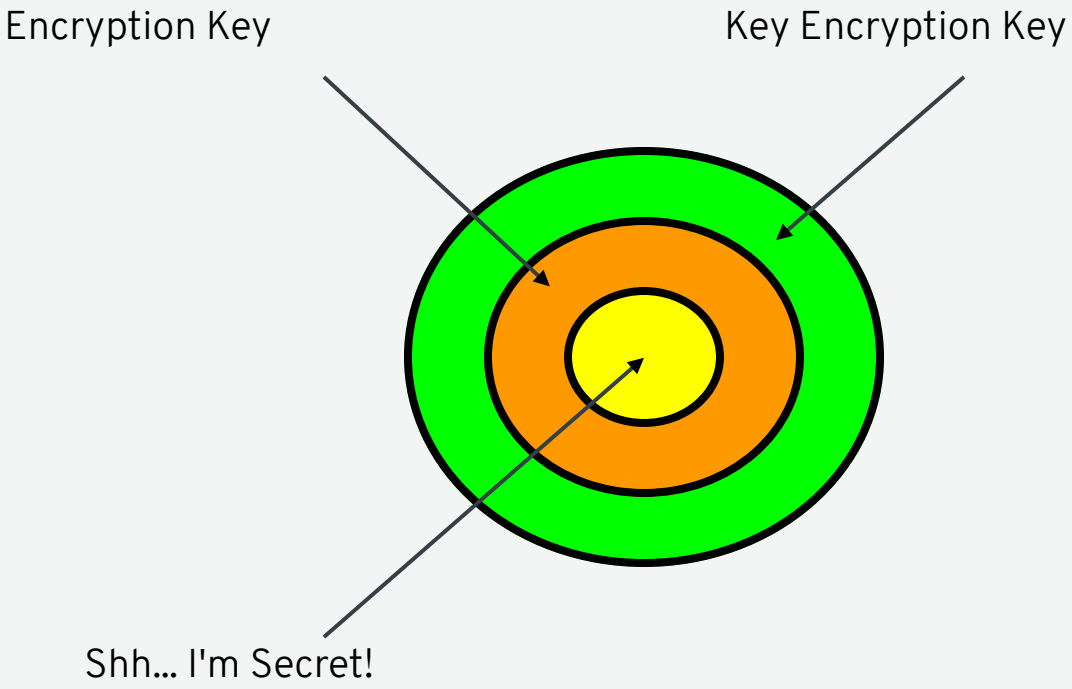

YESTERDAY
TODAY
TOMORROW
Standards (AES, PCI-DSS, etc.)
Automation
Policy

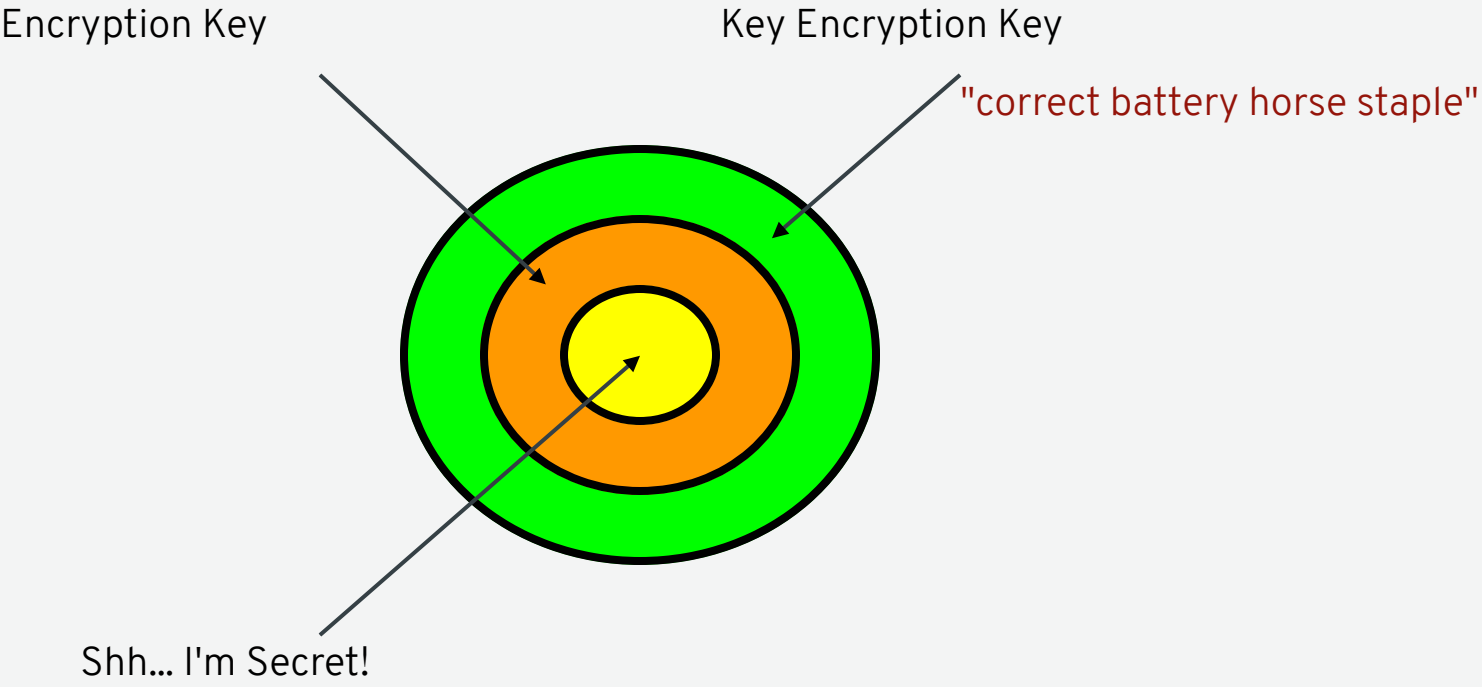
YESTERDAY	TODAY	TOMORROW
Standards (AES, PCI-DSS, etc.)	Automation	Policy

HOW DO WE AUTOMATE?

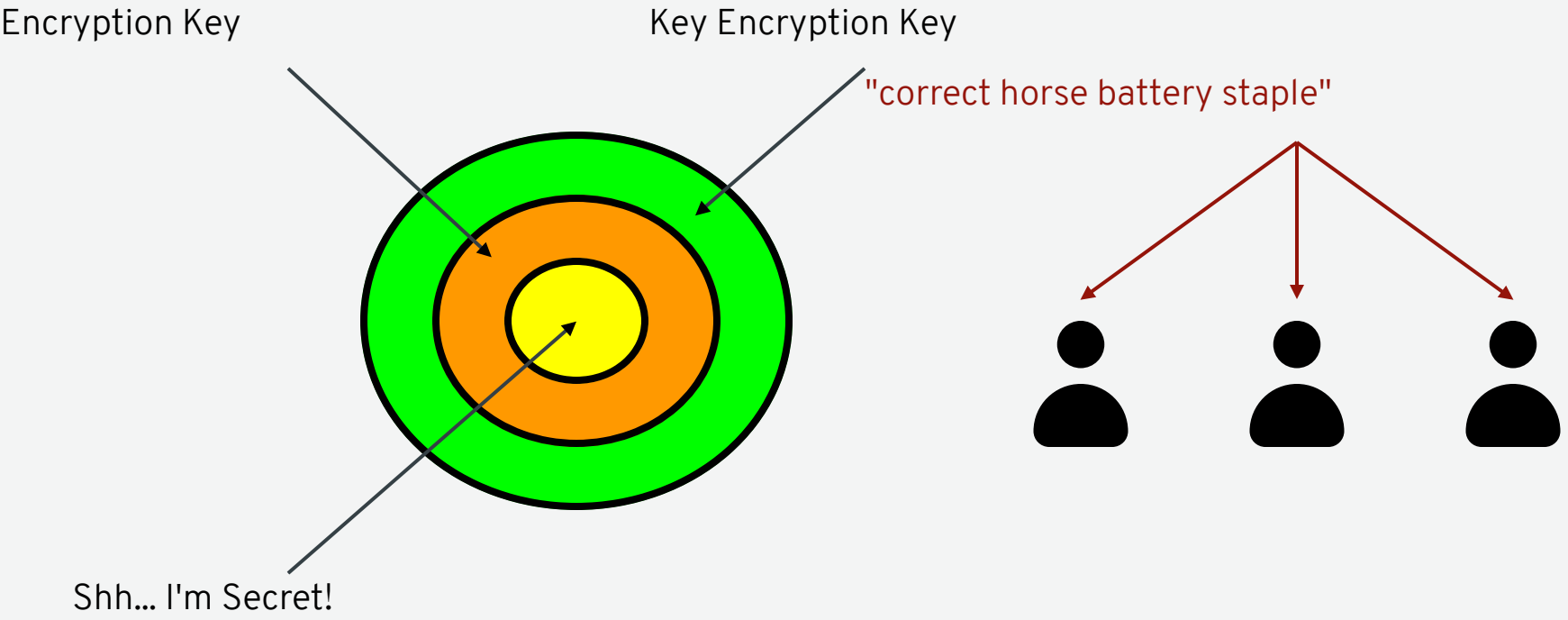

Shh... I'm Secret!

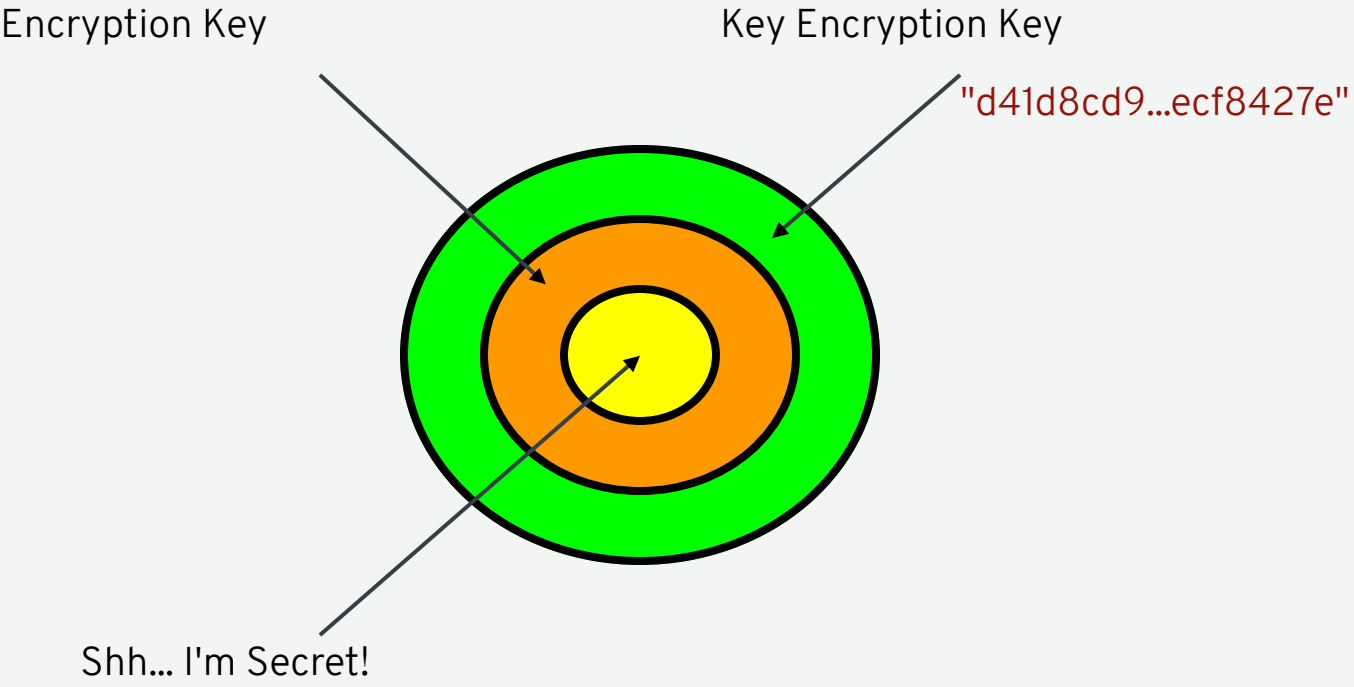

Encryption Key
Shh... I'm Secret!


Encryption Key
Key Encryption Key
Shh... I'm Secret!

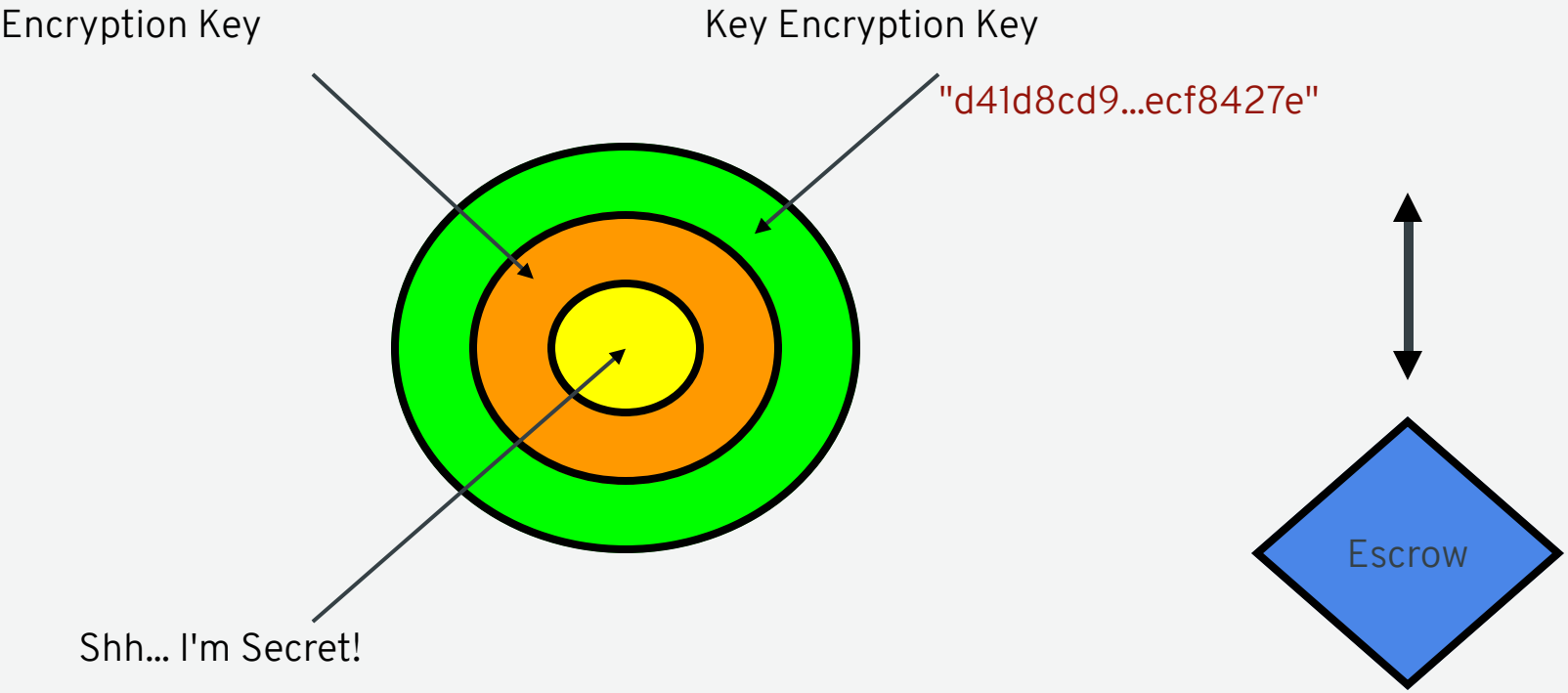

Encryption Key
Key Encryption Key
"correct battery horse staple"
Shh... I'm Secret!

STANDARD PASSWORD MODEL

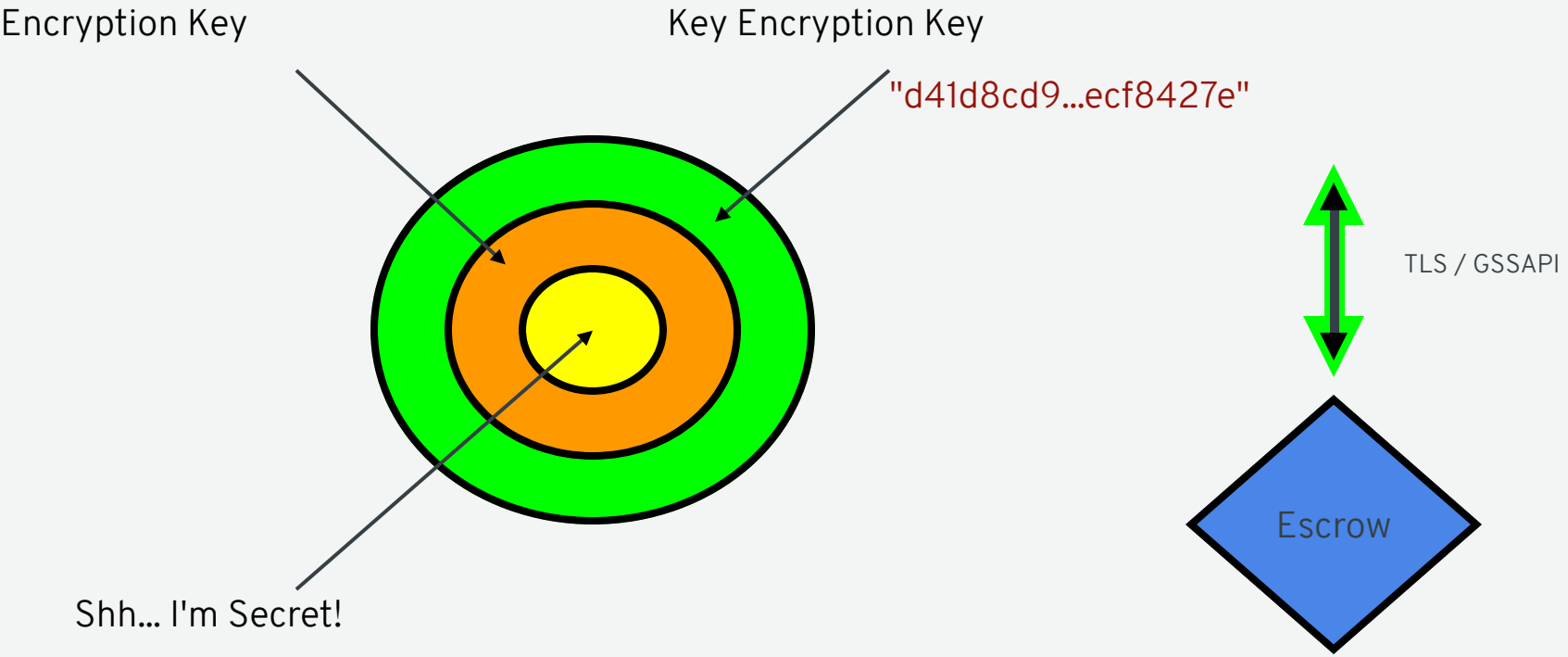



Encryption Key
Key Encryption Key
"d41d8cd9...ecf8427e"
Shh... I'm Secret!

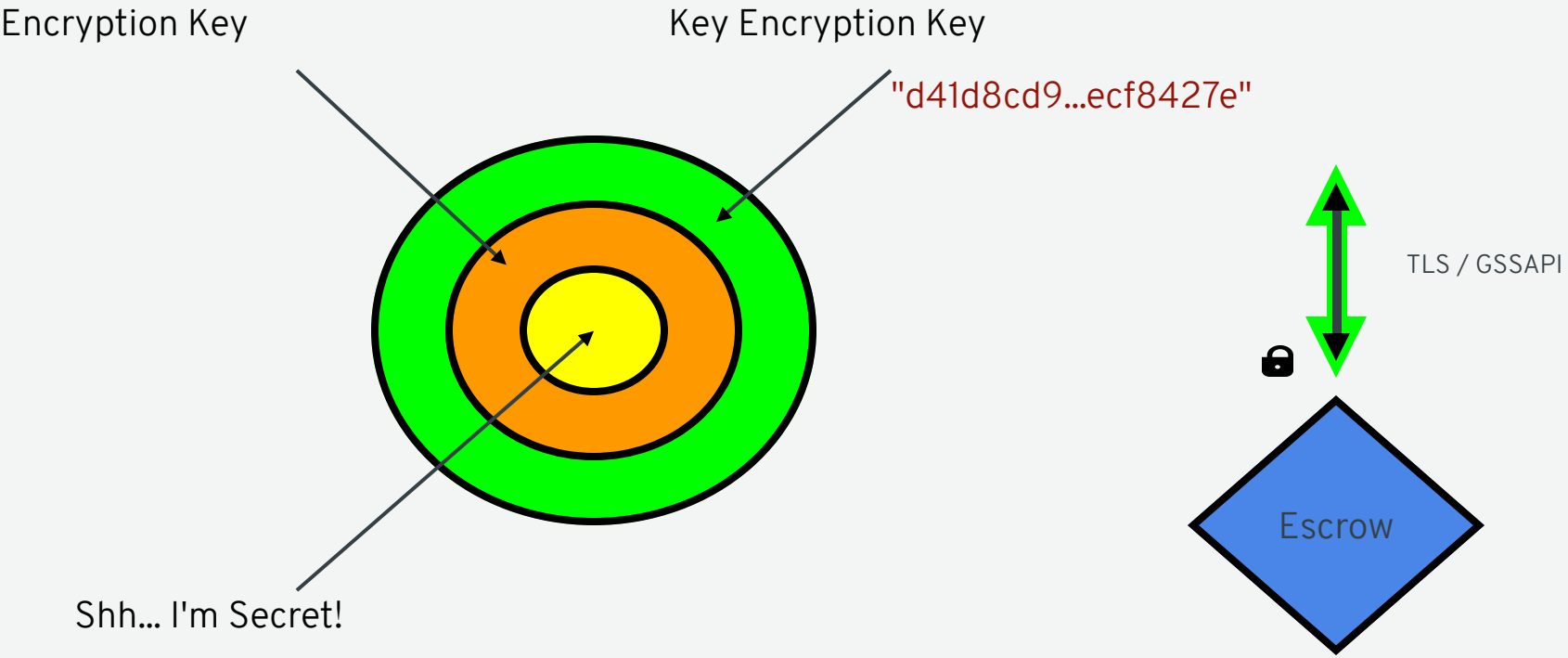
STANDARD ESCROW MODEL?



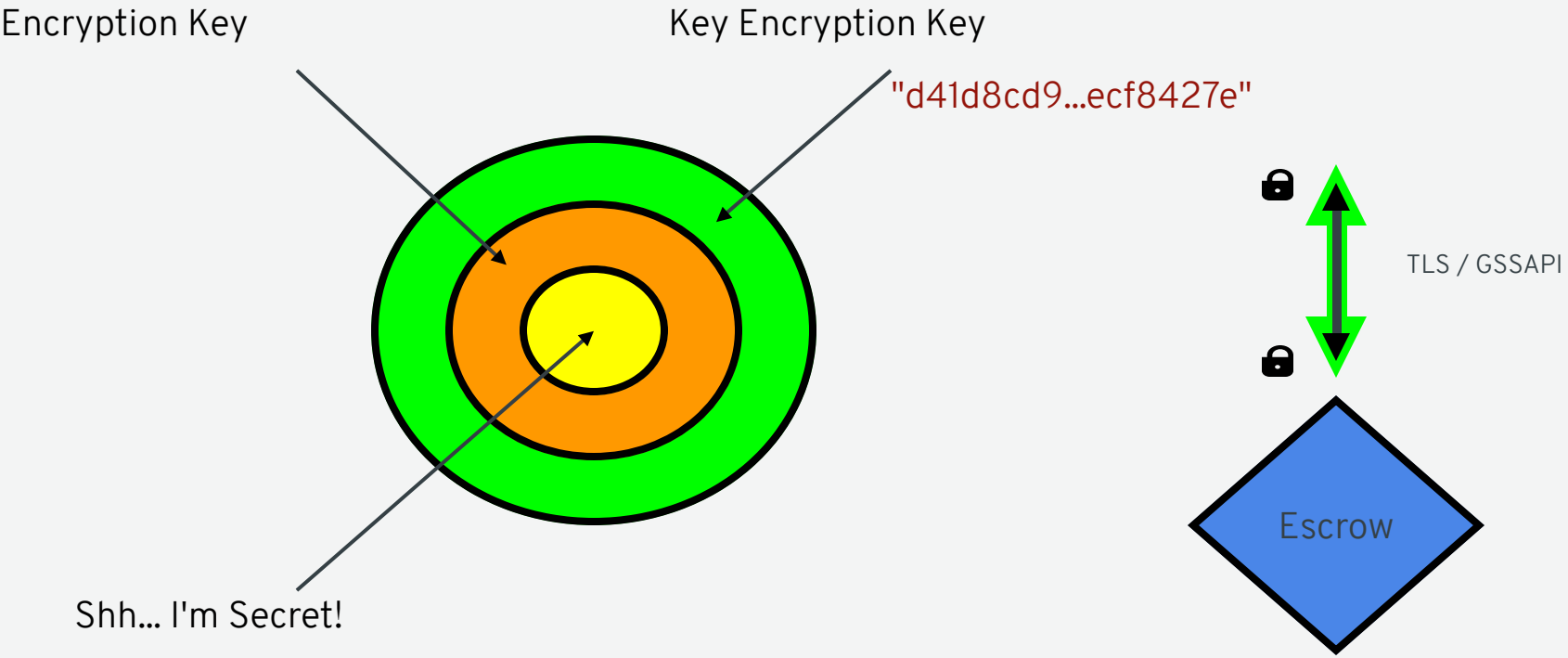
STANDARD ESCROW MODEL?



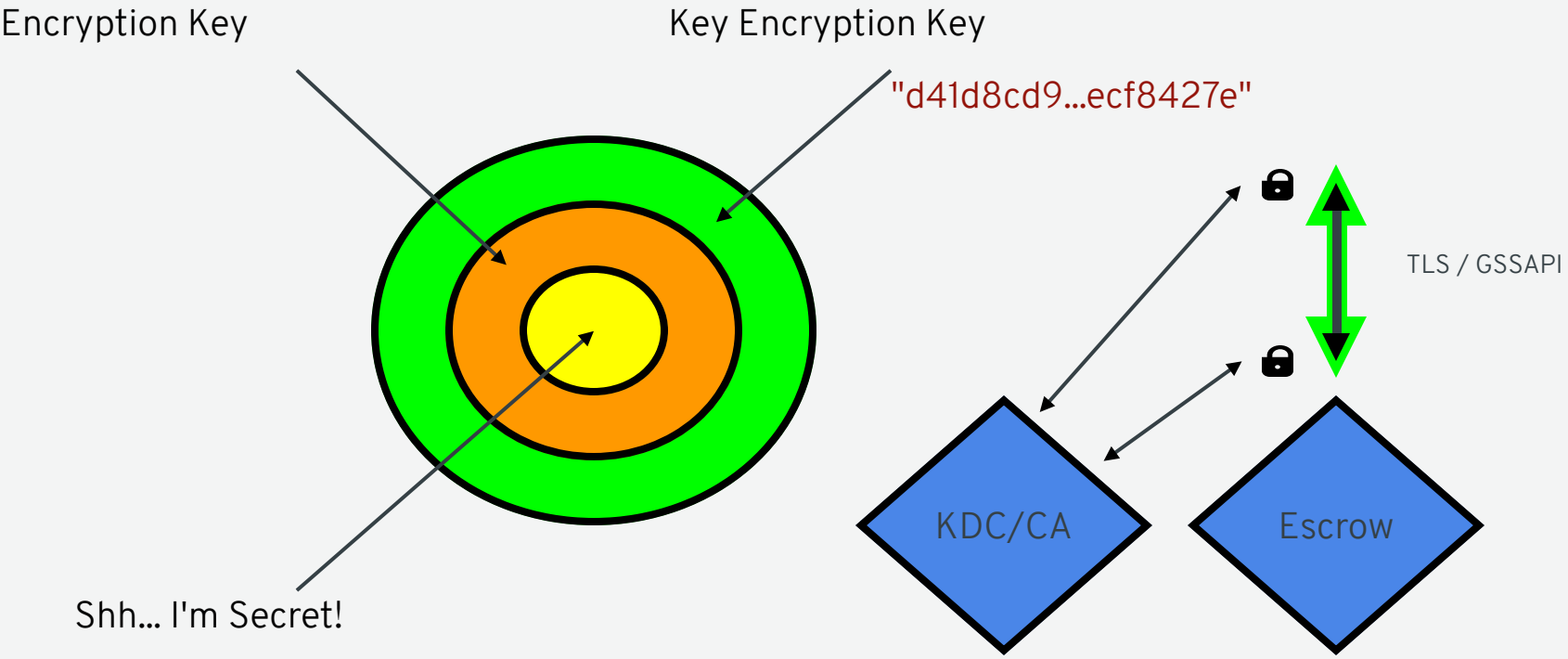
STANDARD ESCROW MODEL?



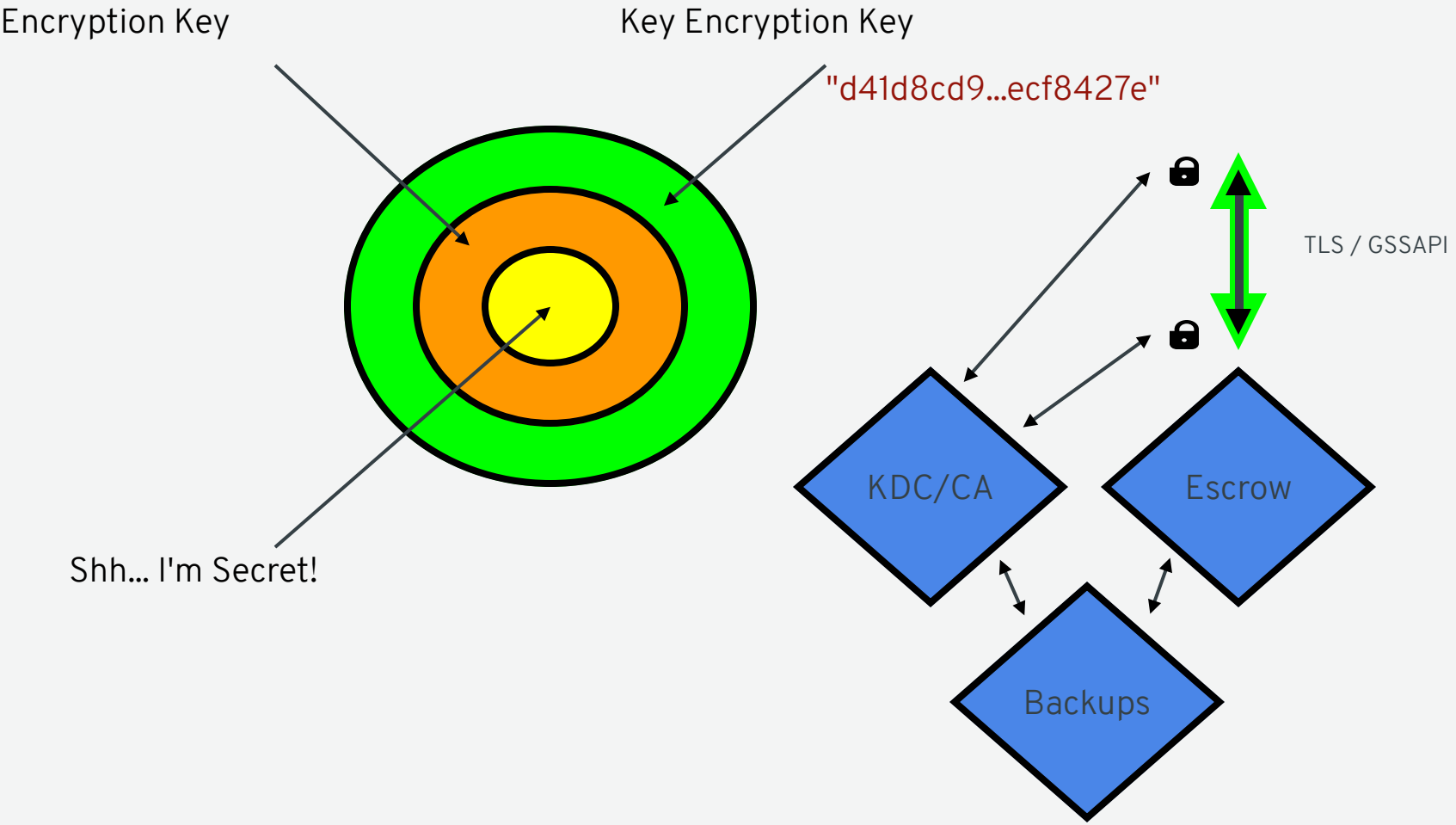
STANDARD ESCROW MODEL?



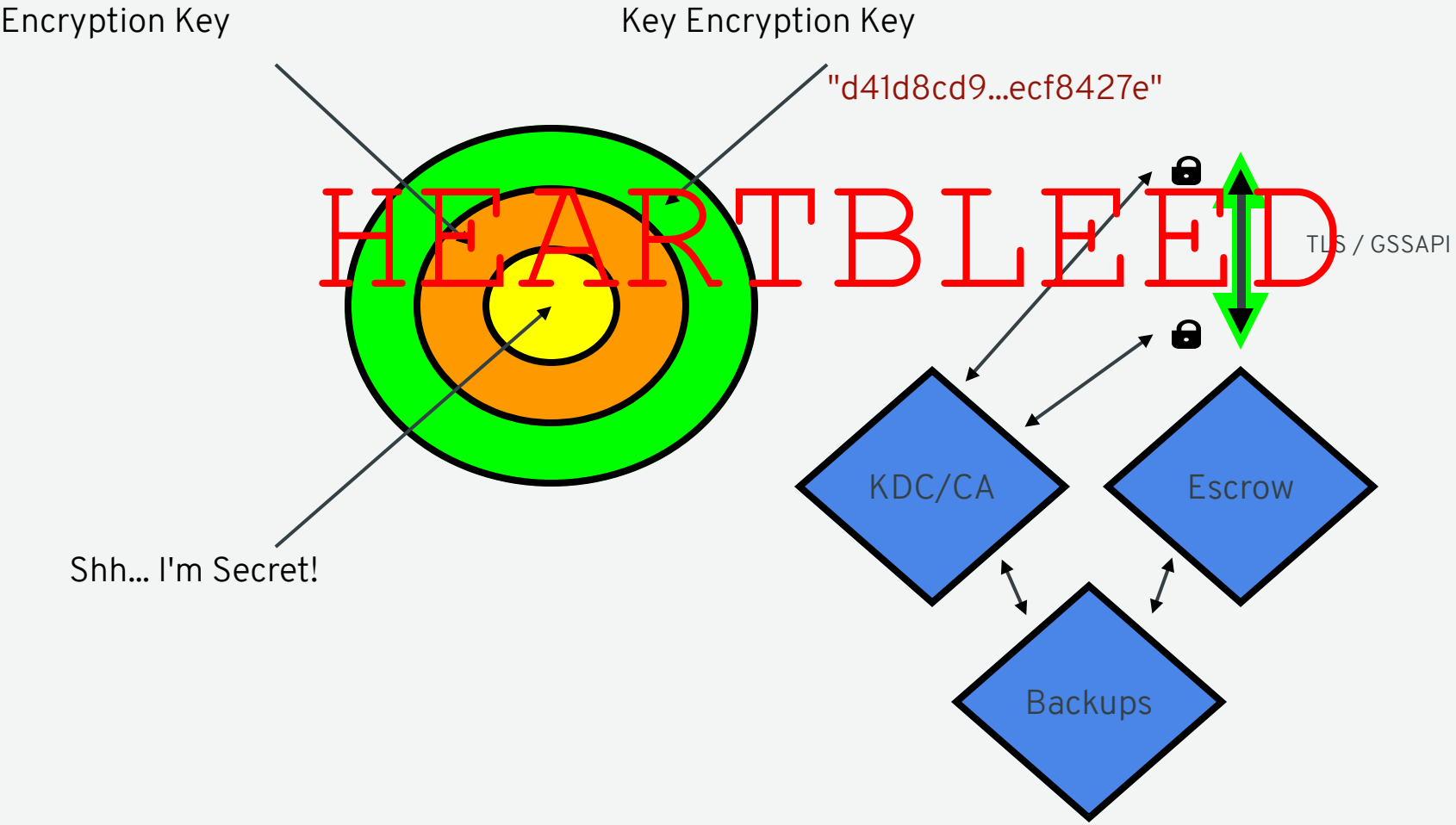
STANDARD ESCROW MODEL?



STANDARD ESCROW MODEL



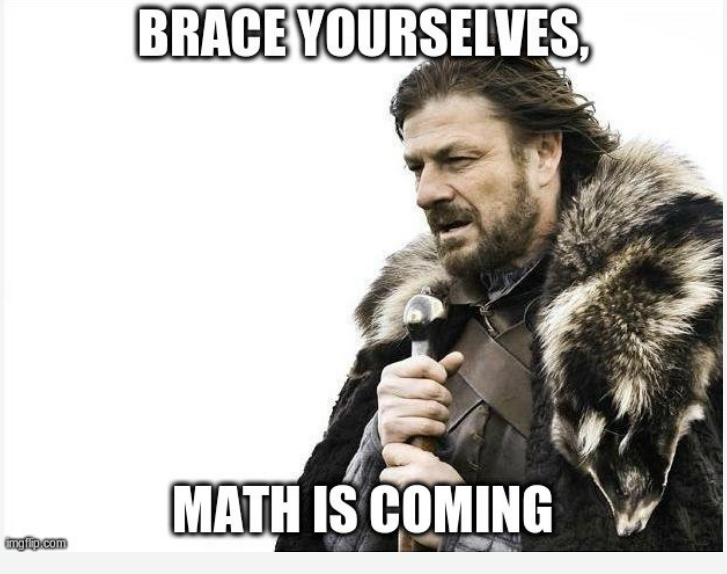
STANDARD ESCROW MODEL



LESSONS LEARNED

- Presuming TLS will protect key transfer is dangerous
- Complexity increases attack surface
- Escrows are difficult to deploy
- X.509 is hard to get right

ASYMMETRIC CRYPTO?


BRACE YOURSELVES,
MATH IS COMING
imgflip.com

(EC) DIFFIE-HELLMAN KEY EXCHANGE

$$
\begin{array}{l|r}
C \in_R [1, p-1] & S \in_R [1, p-1] \\
c = gC & s = gS \\
\qquad\qquad c \longrightarrow & \longleftarrow s \\
K = gSC = sC & K = gCS = cS
\end{array}
$$

BINDING WITH ECDH (INSECURE)

PROVISIONING

$S \in_R [1, p-1]$

$s = gS$

$\longleftarrow s$

$C \in_R [1, p-1]$

$c = gC$

$K = gSC = sC$

$Discard : K, C$

$Retain : s, c$

RECOVERY

$c \longrightarrow$

$K = xS$

$\longleftarrow K$

Weaknesses:

1. K is revealed to a passive attacker.
2. With c, the passive attacker can get K.
3. Server learns c and therefore K.

Resolved: c **MUST** be private

MCCALLUM-RELYEA KEY EXCHANGE

PROVISIONING

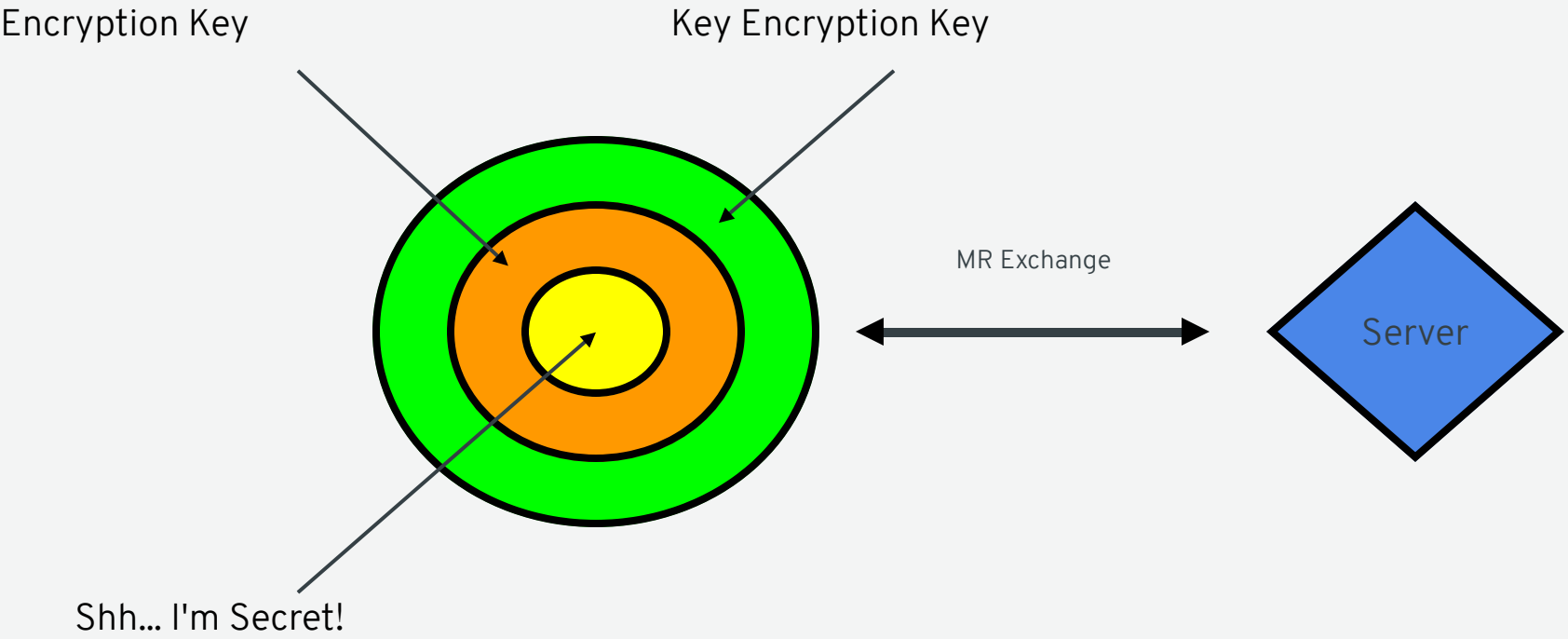
$$
\begin{array}{l|r}
 & S \in_R [1, p-1] \\
 & s = gS \\
 & \longleftarrow s \\
C \in_R [1, p-1] & \\
c = gC & \\
K = gSC = sC & \\
Discard : K, C & \\
Retain : s, c &
\end{array}
$$

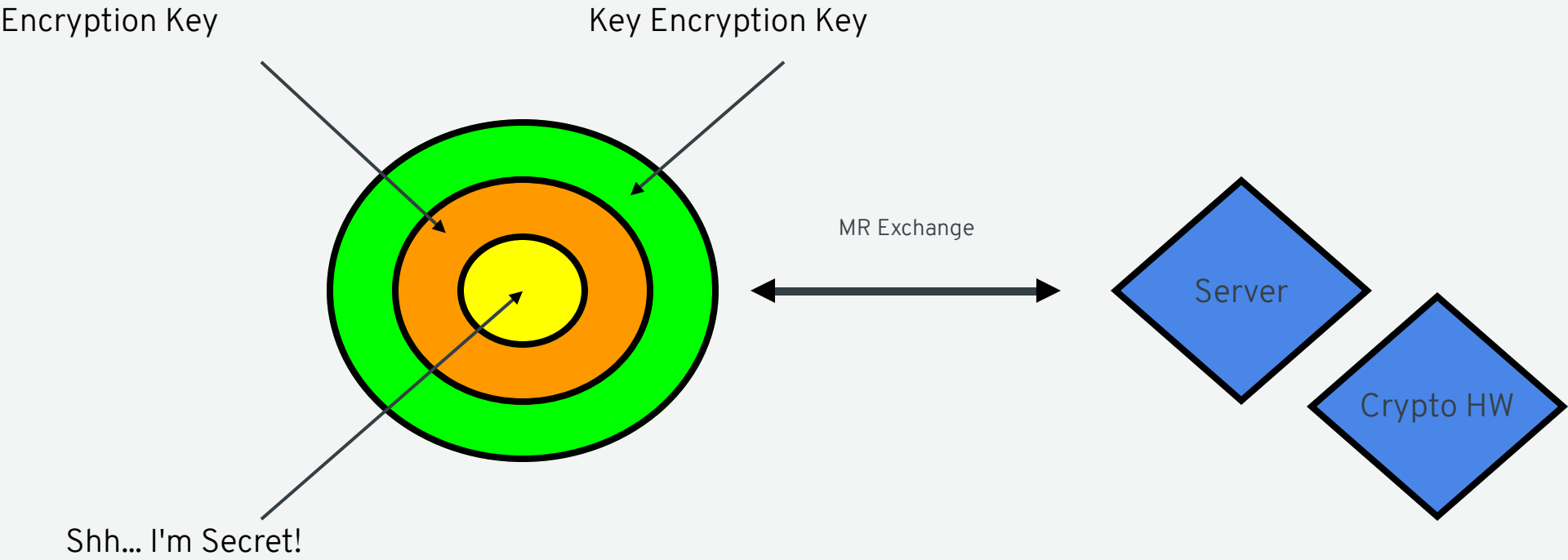
RECOVERY

$$
\begin{array}{l|r}
E \in_R [1, p-1] & \\
e = gE & \\
x = c + e & \\
 & x \longrightarrow \\
 & y = xS \\
 & \longleftarrow y \\
K = y - sE &
\end{array}
$$

$$Because : K = gCS + gES - gSE$$

To keep c private, e & E **MUST** be private.


Encryption Key
Key Encryption Key
MR Exchange
Server
Shh... I'm Secret!


Encryption Key
Key Encryption Key
MR Exchange
Server
Crypto HW
Shh... I'm Secret!

Property	Escrow	MR Exchange
Server presence during provisioning	Required	Optional
Server presence during recovery	Required	Required
Server knowledge of keys	Required	None
Key transfer	Required	None
Client authentication	Required	Optional
Transport encryption	Required	Optional
End-to-end Encryption	Difficult	Unneeded

TANG

- https://github.com/latchset/tang
- Server-side daemon
- Simple: HTTP + JOSE
- Fast (>2k req/sec)
- Extremely small
- Minimal dependencies
- Fedora 26+, RHEL 7.4, Debian (soon)

INSTALLING A TANG SERVER

```
$ sudo dnf install tang
$ sudo systemctl enable --now tangd.socket
```

ON THE CLIENT...

CLEVIS

- https://github.com/latchset/clevis/
- Decryption automation and policy framework
- Minimal dependencies
- Early boot integration
- GNOME integration
- Fedora 26+, RHEL 7.4, Debian (soon)

BASIC ENCRYPTION WITH TANG

```
$ dnf install clevis

$ echo PT | clevis encrypt tang '{"url":"http://localhost"}' > mydata.jwe
The advertisement is signed with the following keys:
        haD7Y-8VkAyJo6-vdZMrGQXCSfI

Do you wish to trust the advertisement? [yN] y

$ cat mydata.jwe
{"ciphertext":"-O59czAqybvxHdme2t3I5A", ...}

$ clevis decrypt < mydata.jwe
PT

$ sudo systemctl stop tangd.socket

$ clevis decrypt < mydata.jwe
$ echo $?
1
```

BASIC ENCRYPTION WITH AN ESCROW

```
$ dnf install clevis

$ echo PT | clevis encrypt http '{"url":"http://localhost/key"}' > mydata.jwe

$ cat mydata.jwe
{"ciphertext":"-O59czAqybvxHdme2t3I5A", ...}

$ clevis decrypt < mydata.jwe
PT
```

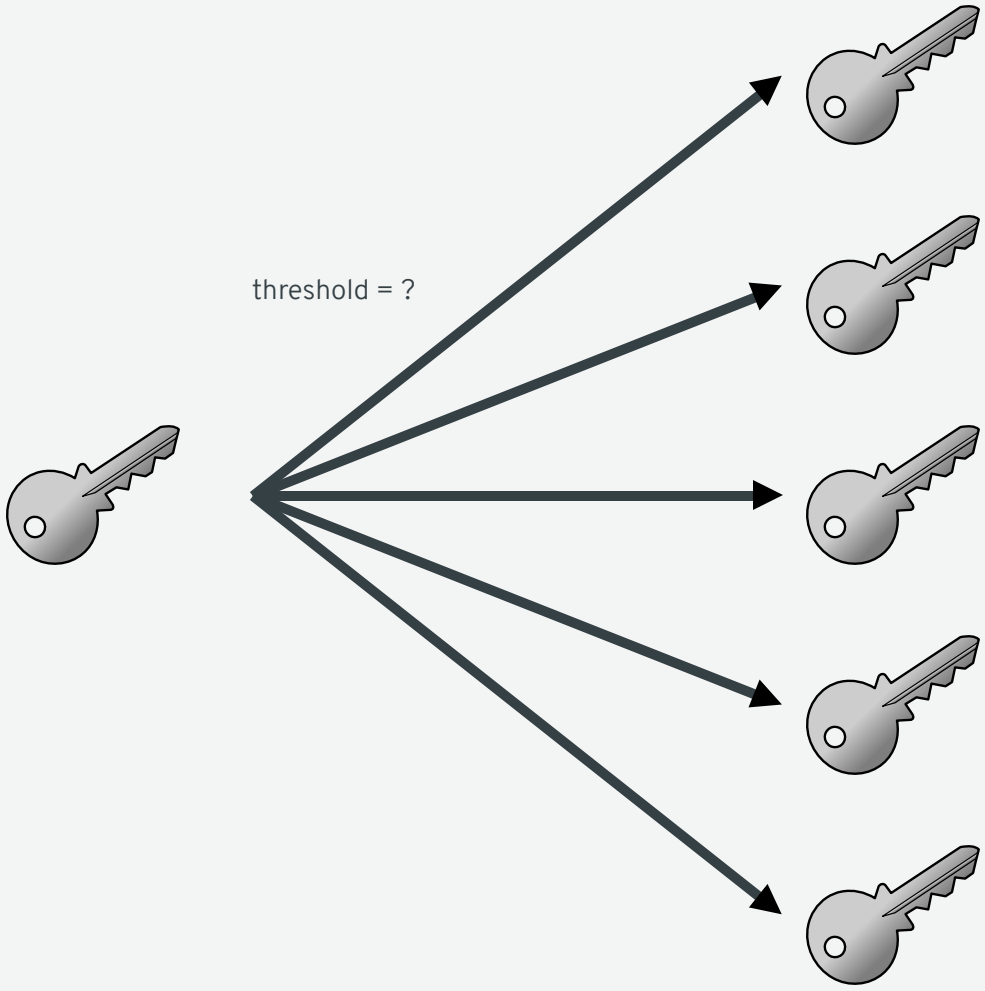
DISK BINDING WITH TANG

```
$ sudo clevis bind luks -d /dev/sda1 tang '{"url":"http://tang.srv"}'
The advertisement is signed with the following keys:
        haD7Y-8VkAyJo6-vdZMrGQXCSfI

Do you wish to trust the advertisement? [yN] y
Enter passphrase for /dev/sda1:

$ sudo luksmeta show -d /dev/sda1
0   active empty
1   active cb6e8904-81ff-40da-a84a-07ab9ab5715e
2 inactive empty
3 inactive empty
...

# For root volume unlocking at boot:
$ sudo dnf install clevis-dracut
$ sudo dracut -f
$ reboot

# For removable storage GNOME unlocking:
$ sudo dnf install clevis-udisks2
```

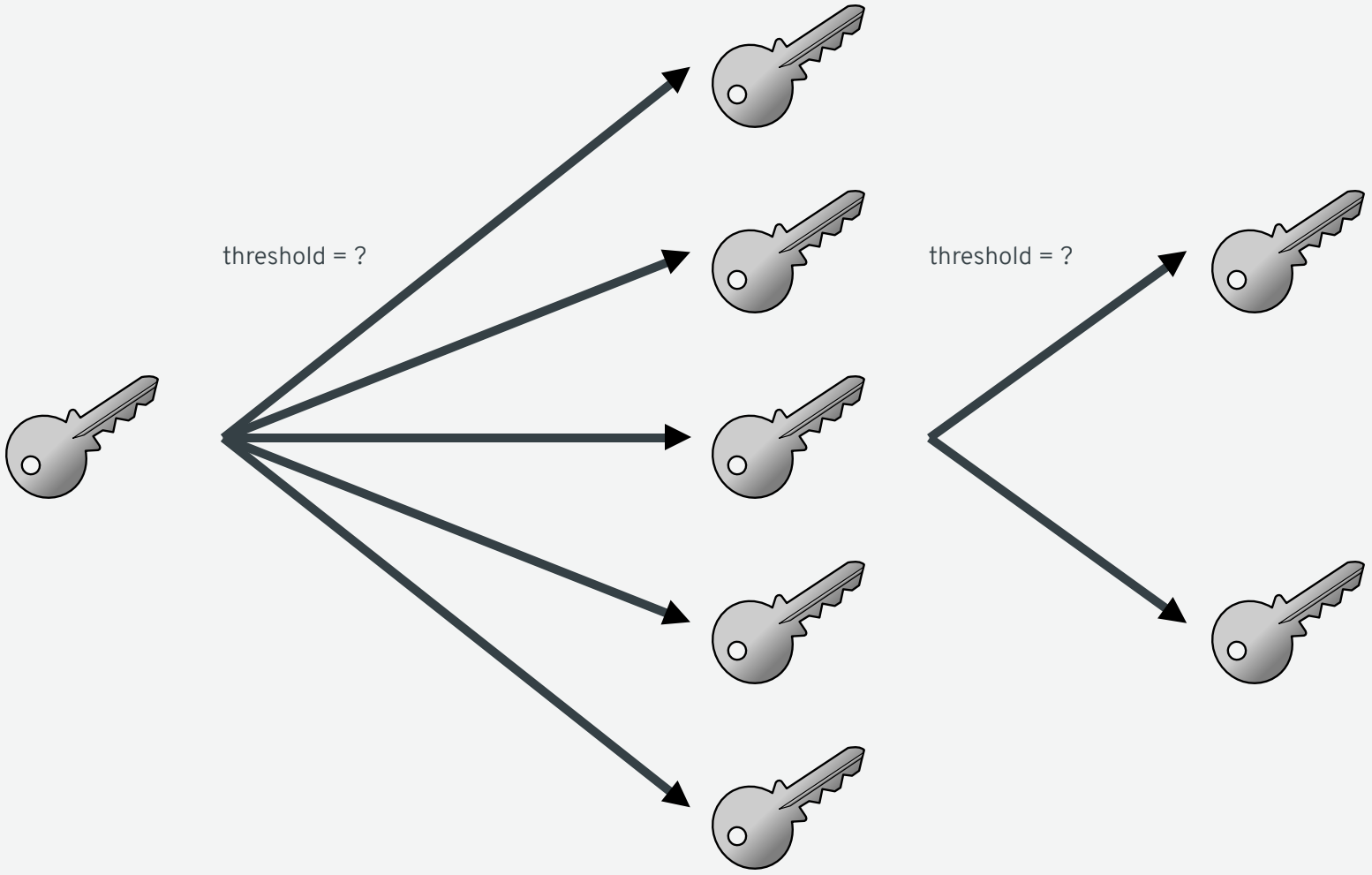
FROM AUTOMATION TO POLICY

YESTERDAY	TODAY	TOMORROW
Standards (AES, PCI-DSS, etc.)	Automation	Policy

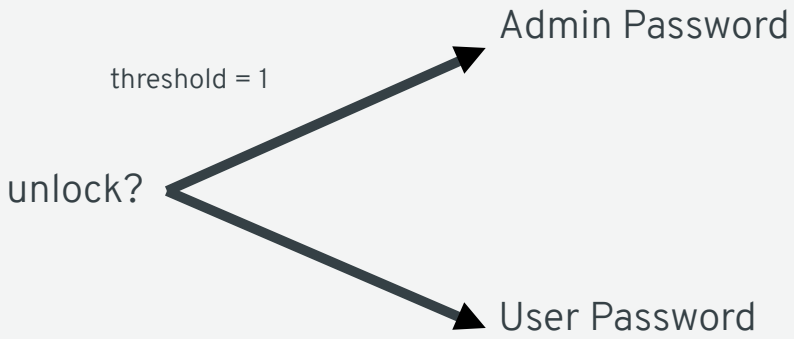
SHAMIR SECRET SHARING



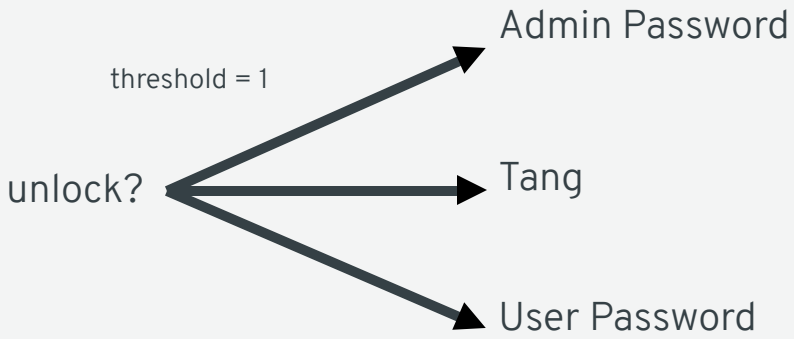
SHAMIR SECRET SHARING



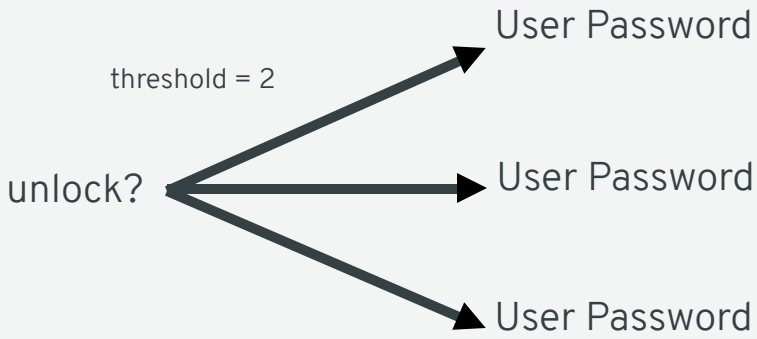
SIMPLE LAPTOP



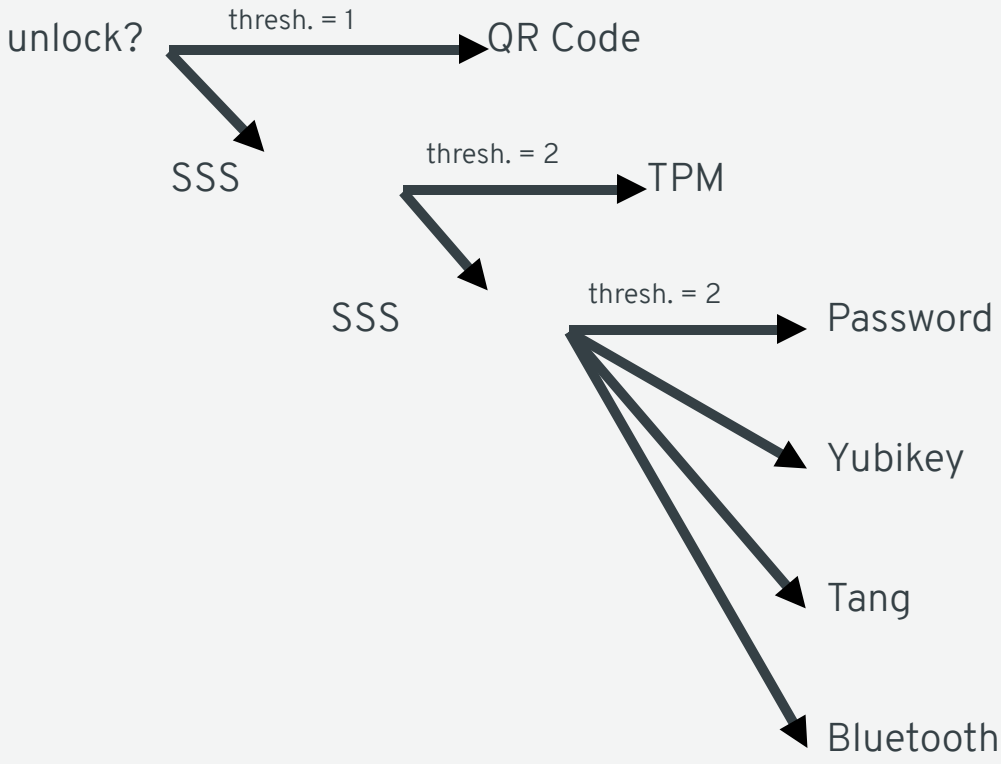
AUTOMATED LAPTOP



HIGH SECURITY SYSTEM



SOPHISTICATED LAPTOP POLICY



BASIC SHAMIR'S WITH TANG

```
$ echo PT | clevis encrypt sss \
'{"pins": {"tang": [{"url": "http://a.tang.srv"}, {"url": "http://b.tang.srv"}]}, "t": 1}' \
> out.jwe
The advertisement is signed with the following keys:
        haD7Y-8VkAyJo6-vdZMrGQXCSfI

Do you wish to trust the advertisement? [yN] y

The advertisement is signed with the following keys:
        Edp-ESShUx4_95kGt-DTsCBbPag

Do you wish to trust the advertisement? [yN] y

$ clevis decrypt < out.jwe
PT

# Bring Down Tang Server A
$ clevis decrypt < out.jwe
PT

# Bring Down Tang Server B
$ clevis decrypt < out.jwe
$ echo $?
1
```

EXPLORING THE ECOSYSTEM

DEPENDENCY: JOSÉ

- https://github.com/latchset/jose
- JSON Object Signing and Encryption
- C Library & Command Line Utility
- Bottom Line: User-Friendly, Standards Compliant Crypto

```
$ jose jwk gen -i '{"alg": "A128GCM"}' -o oct.jwk
$ jose jwk gen -i '{"alg": "RSA1_5"}' -o rsa.jwk
$ jose jwk gen -i '{"alg": "ES256"}' -o ec.jwk

$ echo hi | jose jwe enc -i- -k rsa.pub.jwk -o msg.jwe
$ jose jwe dec -i msg.jwe -k rsa.jwk
hi
$ jose jwe dec -i msg.jwe -k oct.jwk
Decryption failed!

$ echo hi | jose jws sig -i- -k ec.jwk -o msg.jws
$ jose jws ver -i msg.jws -k ec.pub.jwk
hi
$ jose jws ver -i msg.jws -k oct.jwk
No signatures validated!
```

DEPENDENCY: LUKSMETA

- https://github.com/latchset/luksmeta
- Store metadata in LUKSv1 header gap
- C library & Command Line Utility

```
$ echo hi | luksmeta save -d /dev/sdc1 -s 2 -u EC998562-B60D-47F0-A579-DCA8C12F5BF6

$ luksmeta load -d /dev/sdc1 -s 2 -u EC998562-B60D-47F0-A579-DCA8C12F5BF6
hi

$ luksmeta load -d /dev/sdc1 -s 2 -u 12618962-A1E5-48F1-B327-D7C60E20FC02
Slot contains different UUID
```

THE NEAR FUTURE

JOSÉ

- PKCS#11 Support
- Python Bindings
- Additional crypto backends
- Additional algorithms

CLEVIS

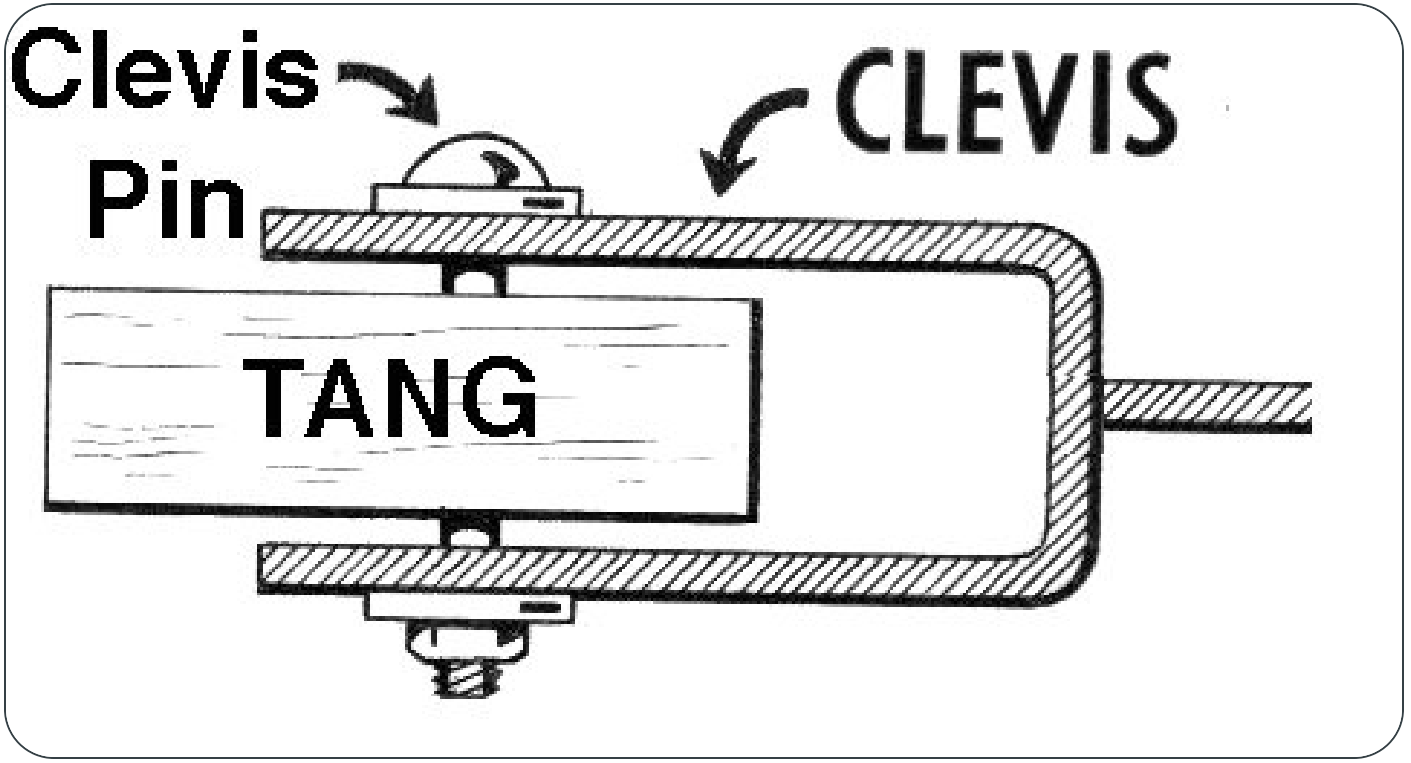
- Password Pin (Issue #52)
- PKCS#11 Pin
- Ext4 encryption support

TANG

- Binding IDs (Optional; sacrifices anonymity)
- Revocation (requires Binding IDs)

PATCHES WELCOME!

QUESTIONS?



Slides: https://redhat.slides.com/tscherf/sad

Credits go to Nathaniel McCallum, author of Clevis/Tang and this slide deck.