Lecture Outline

- Announcements:
  - Homework for next week out by this evening
  - Guest lecture a week from Friday
    - Bill Marczak on *Abusive Surveillance*

- Today: broader notions relating to authentication
  - Architecting to resist subverted clients
  - Imprinting
  - Multi-party identities (Ecommerce, web advertising)
  - Bot-or-Not (CAPTCHAs)

Architecting to
Resist Subverted Clients

Threats?

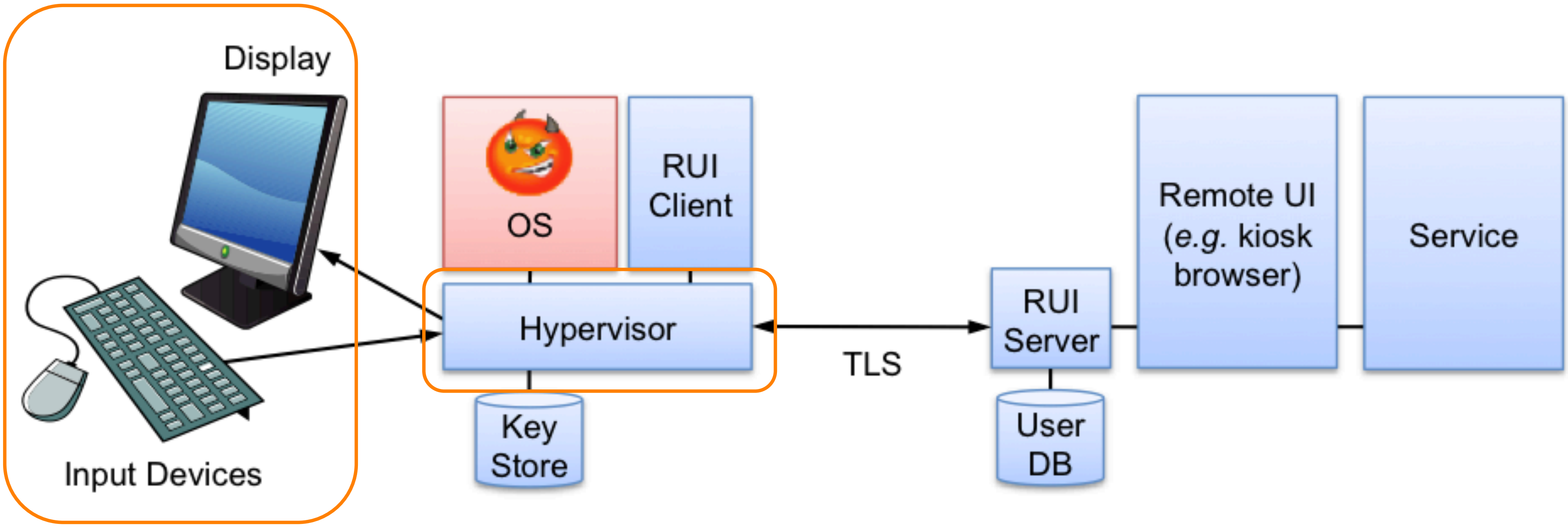
- Sniffing, MITM (network; app-level relay)
  ⇒ Theft of password and/or authenticator
- 3rd-party manipulation of automation
  – E.g. CSRF (browser fetching of images)
  – E.g. XSS (browser execution of JS replies)
- Password security
  – Blind guessing / bruteforcing
  – Reuse (breaches)
  – Phishing
- Compromised client: hijacking

Tackling *Transaction Generators*?

- How about using a separate system?
  - Very inconvenient

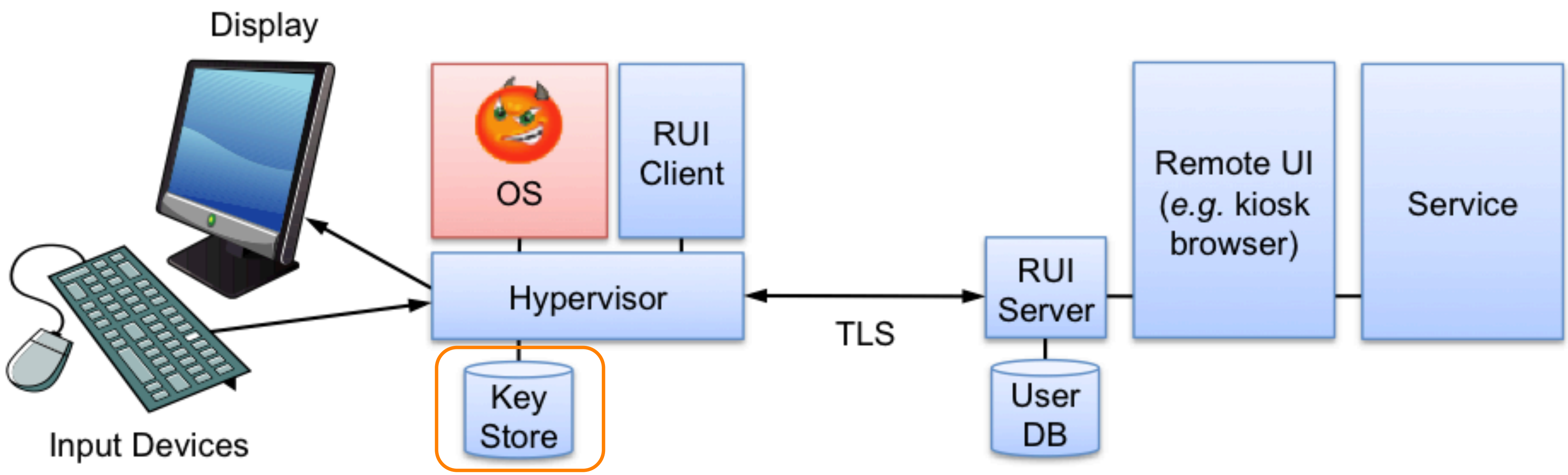
- Desired properties:
  - Compatible w/ existing legacy OS's
  - Can run general web applications
  - No need to trust host OS
  - Small TCB: attestable via TPM

Cloud Terminal Architecture



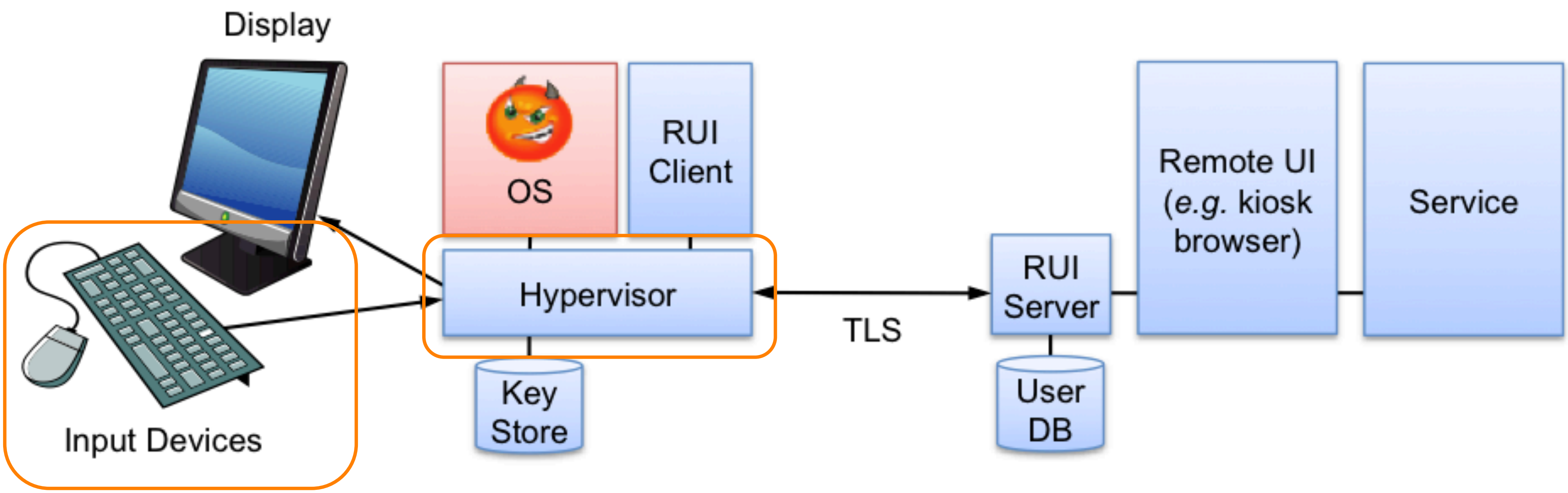
Trusted hypervisor mediates
all physical I/O events

Cloud Terminal Architecture



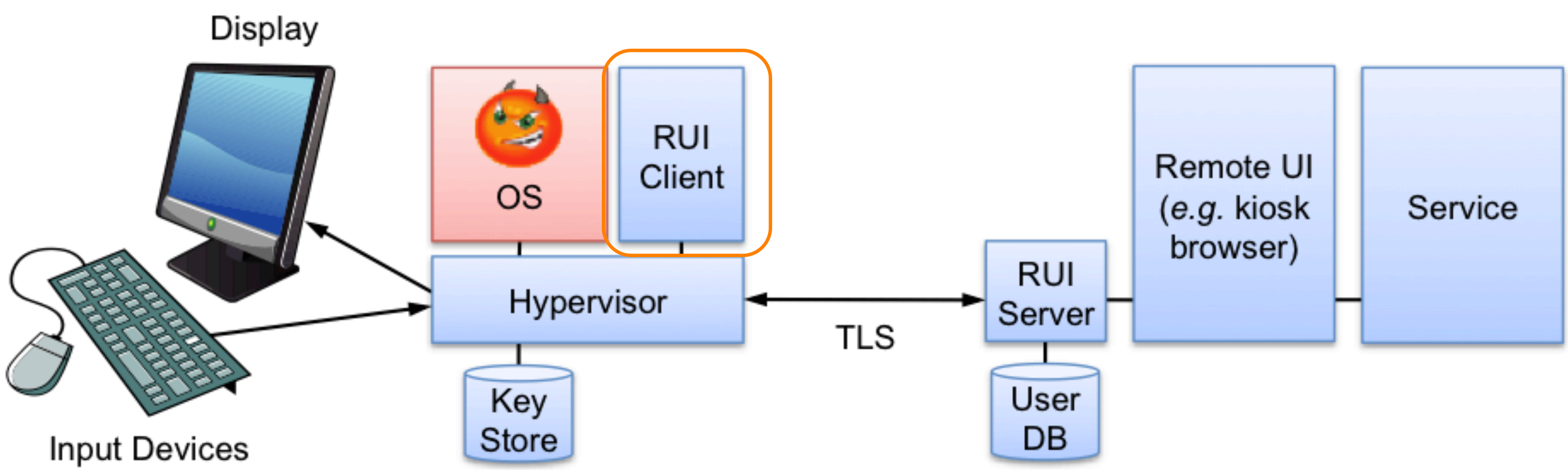
Only hypervisor has access to user's credentials: the user *doesn't know their own passwords*

Cloud Terminal Architecture



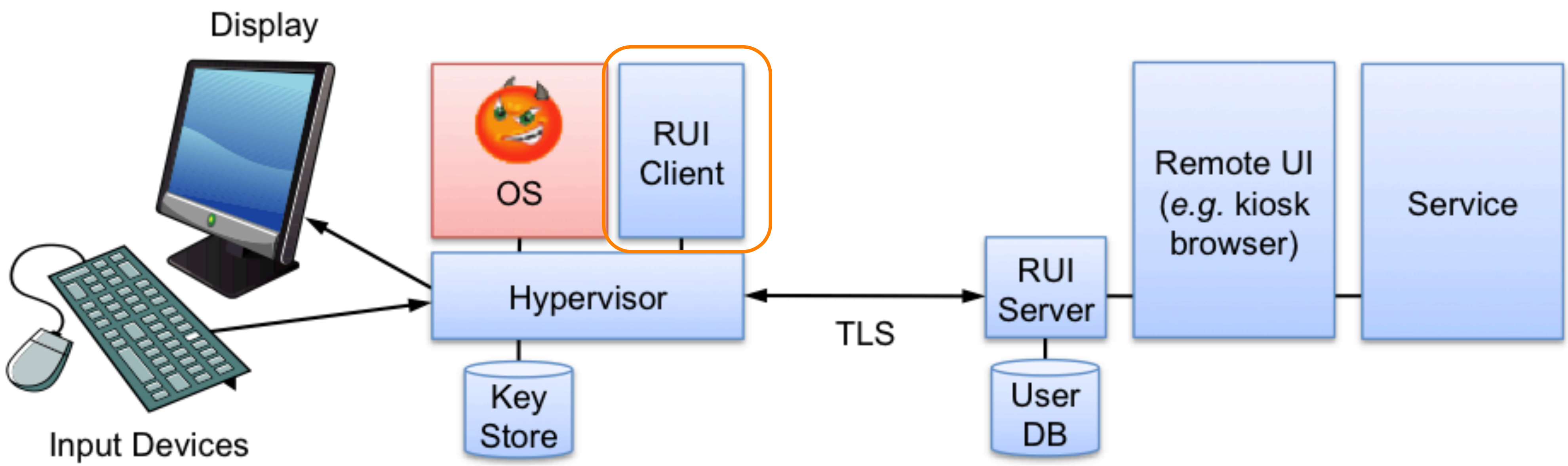
User signals Hypervisor to begin a secure session using a specific hardware keystroke combination ("Secure Attention Key")

Cloud Terminal Architecture



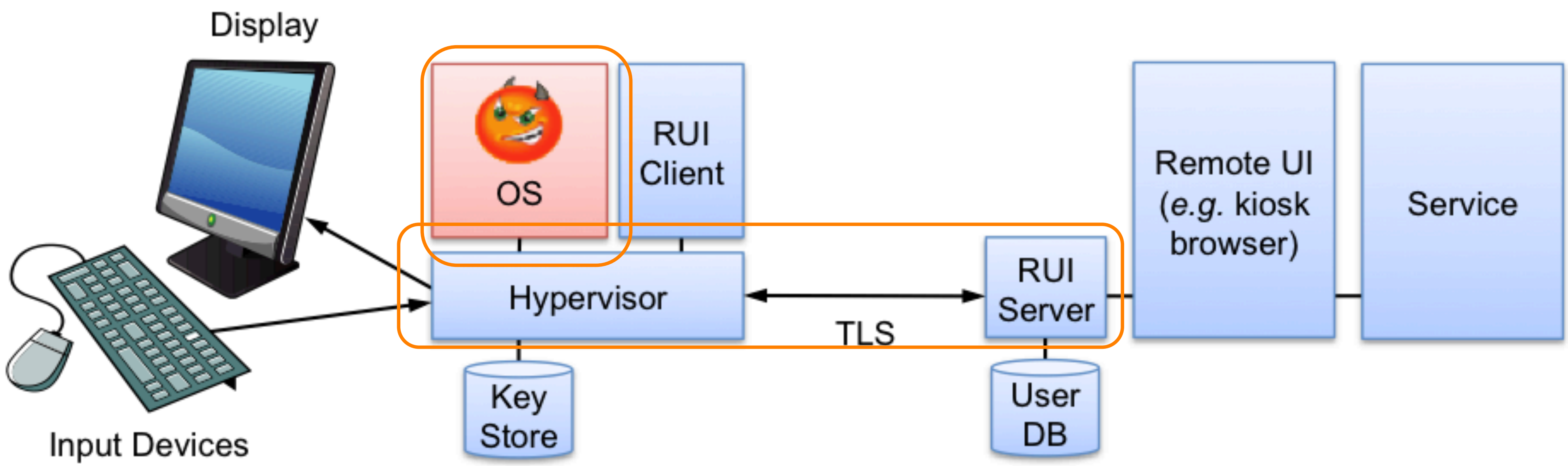
Upon this request, a “thin client” UI runs *in the hypervisor context* (= trusted)

Cloud Terminal Architecture



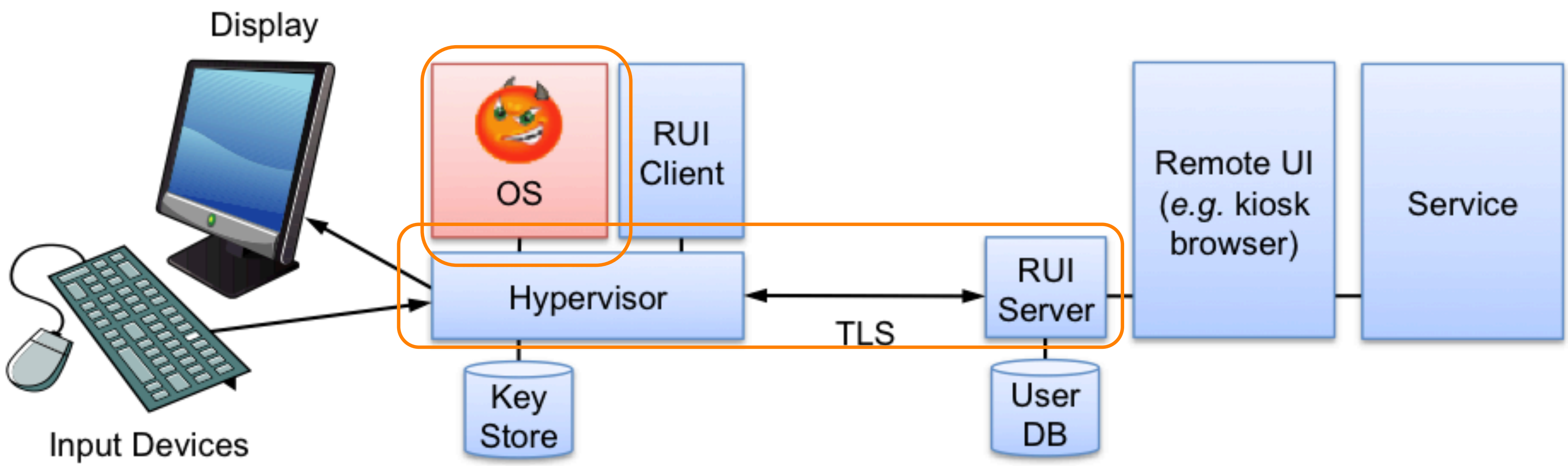
It's locked down to only talk to services **previously registered** with the Hypervisor – *user can't be phished*

Cloud Terminal Architecture



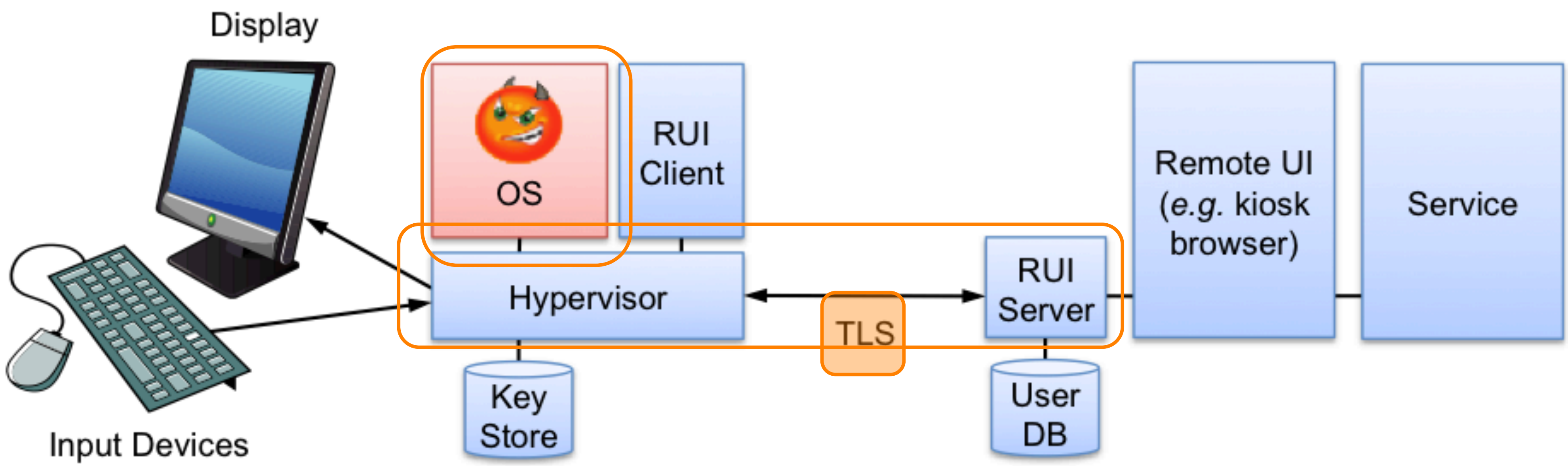
After selecting which service to interact with (e.g., user's **bank**), Hypervisor interacts using **untrusted host OS** for networking & storage

Cloud Terminal Architecture



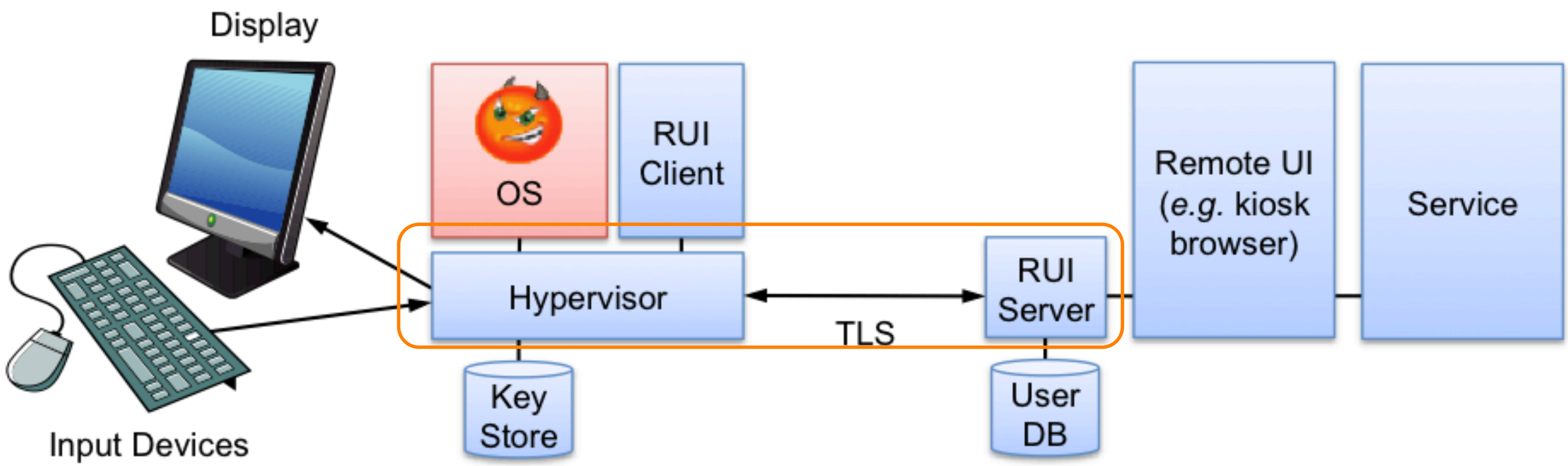
Doing so **reduces TCB**

Cloud Terminal Architecture



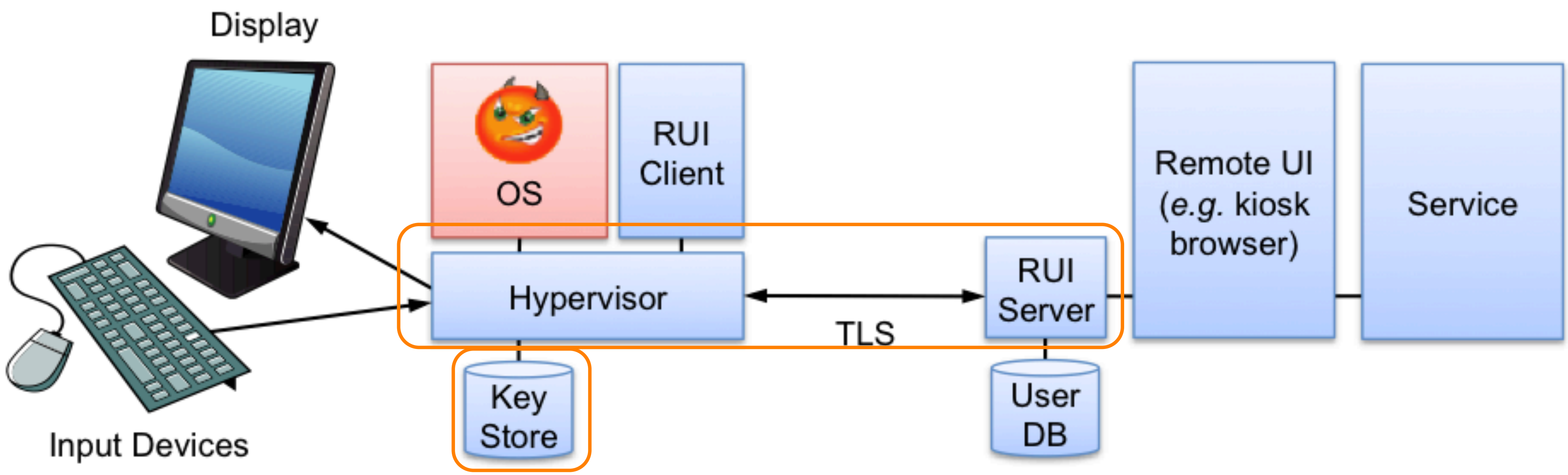
End-to-end encryption obviates need to trust host OS; only threat is DoS

Cloud Terminal Architecture



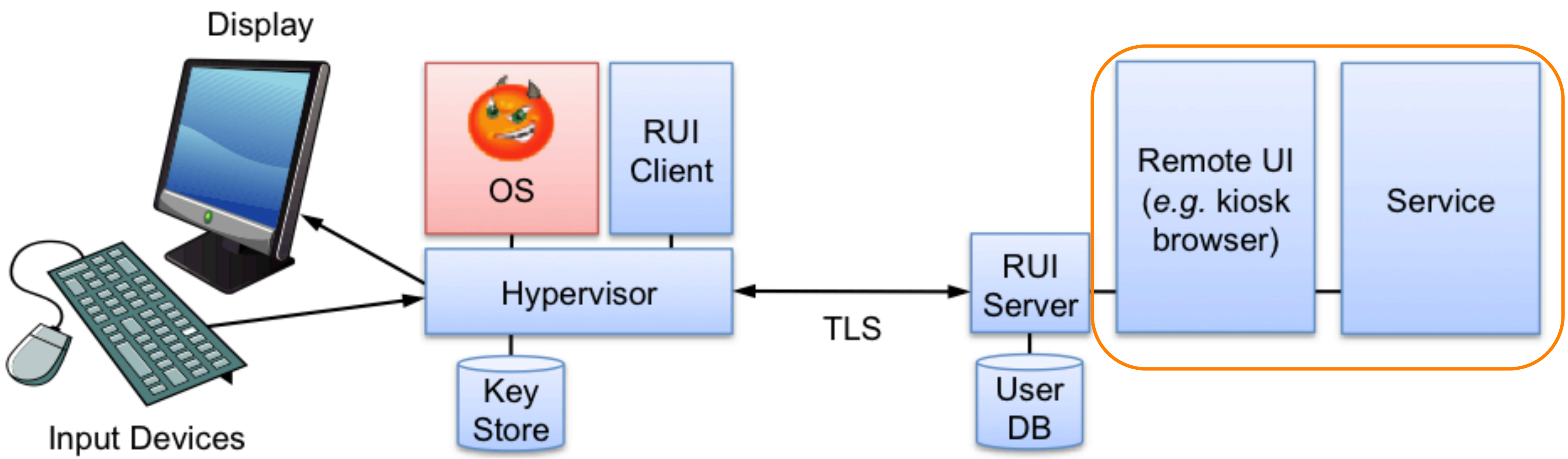
Hypervisor ensures authenticity of remote service by (correctly) validating TLS certificate

Cloud Terminal Architecture



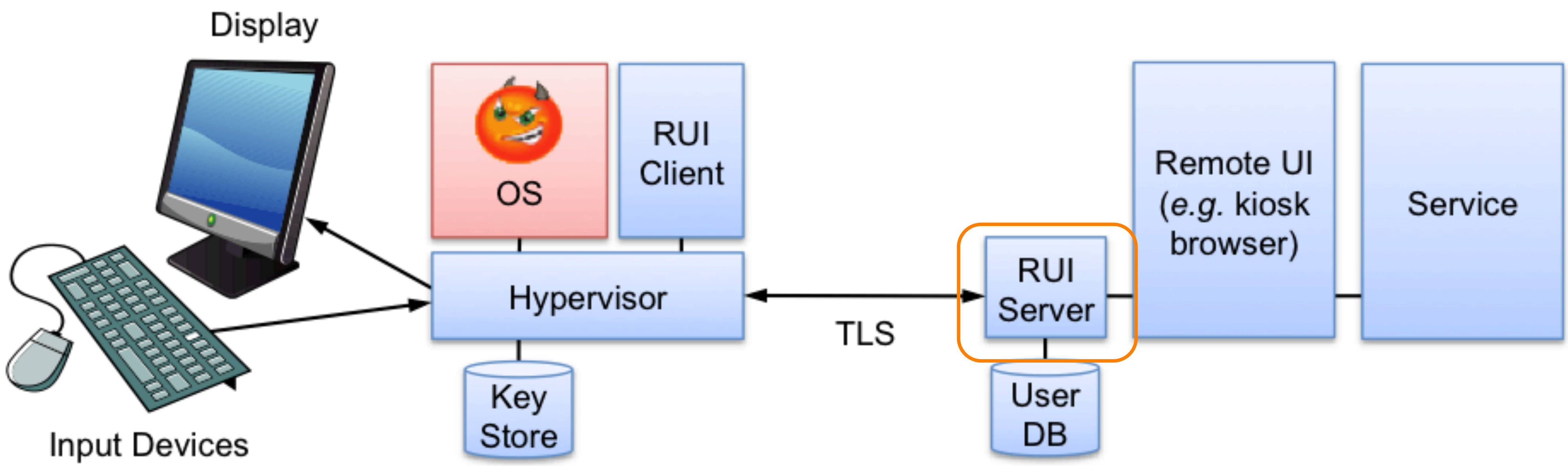
Hypervisor authenticates user to service using password in key store

Cloud Terminal Architecture



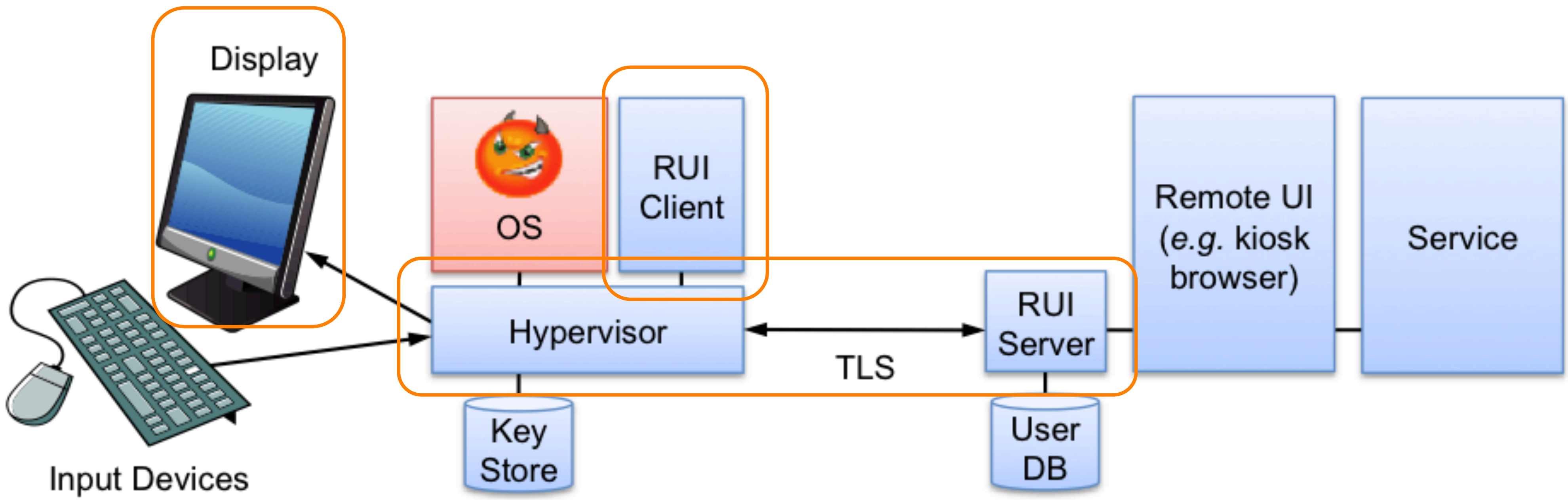
Remote service (e.g., user's **bank**) renders interaction UI *locally* using kiosk software

Cloud Terminal Architecture



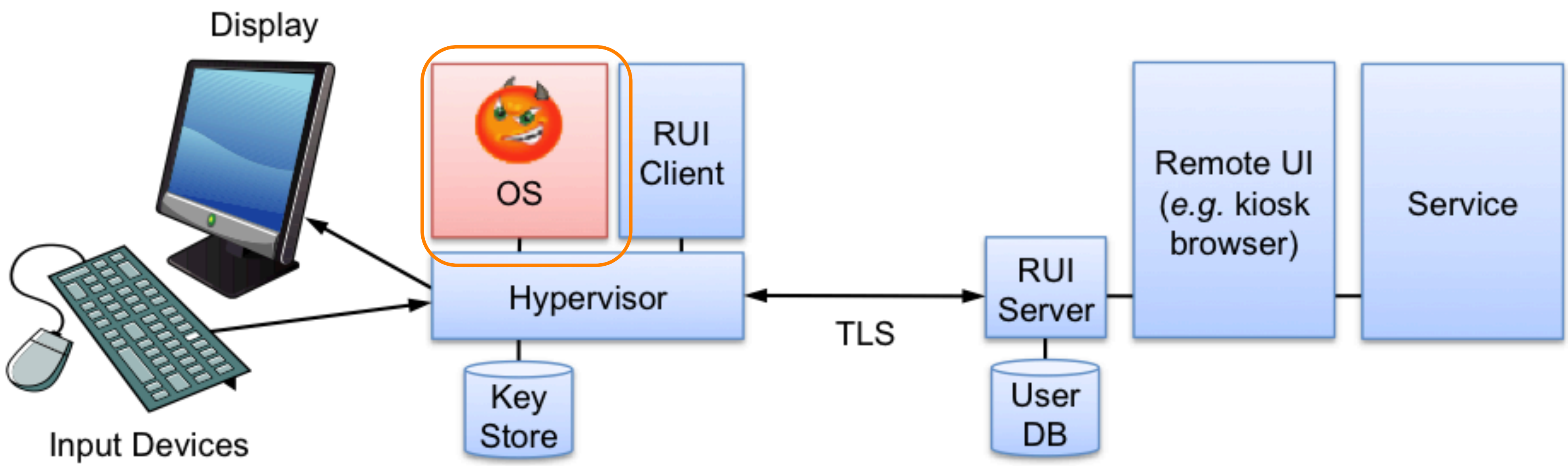
UI is presented to user using VNC-style low-level frame buffer protocol

Cloud Terminal Architecture



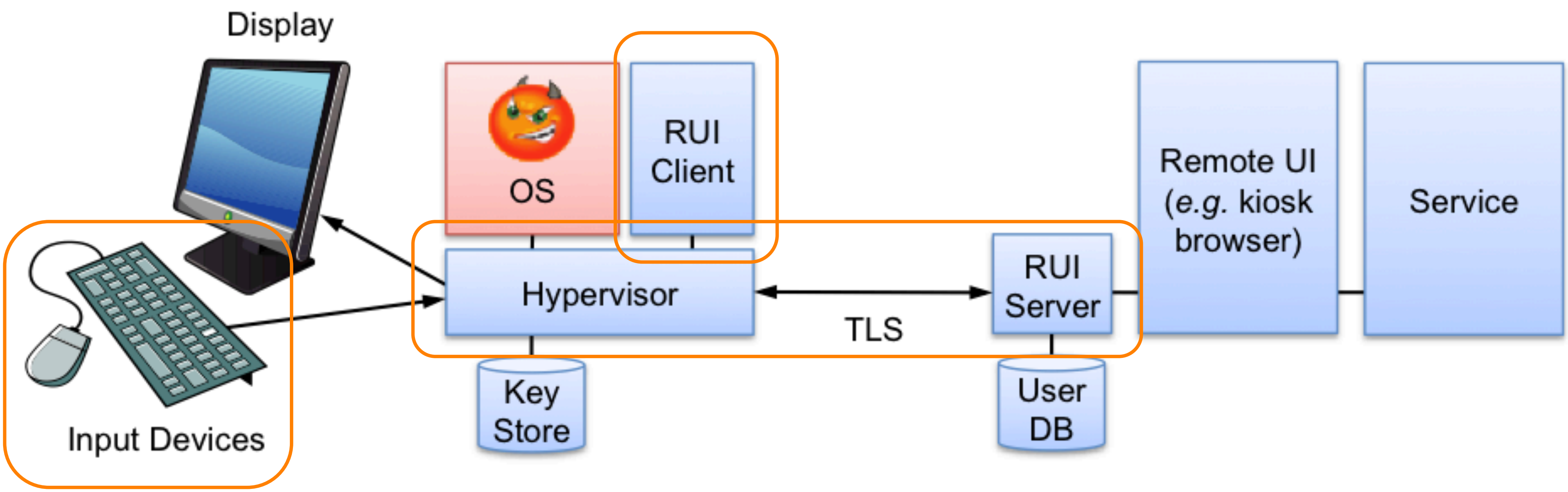
Rendered directly into video
hardware by RUI client + hypervisor

Cloud Terminal Architecture



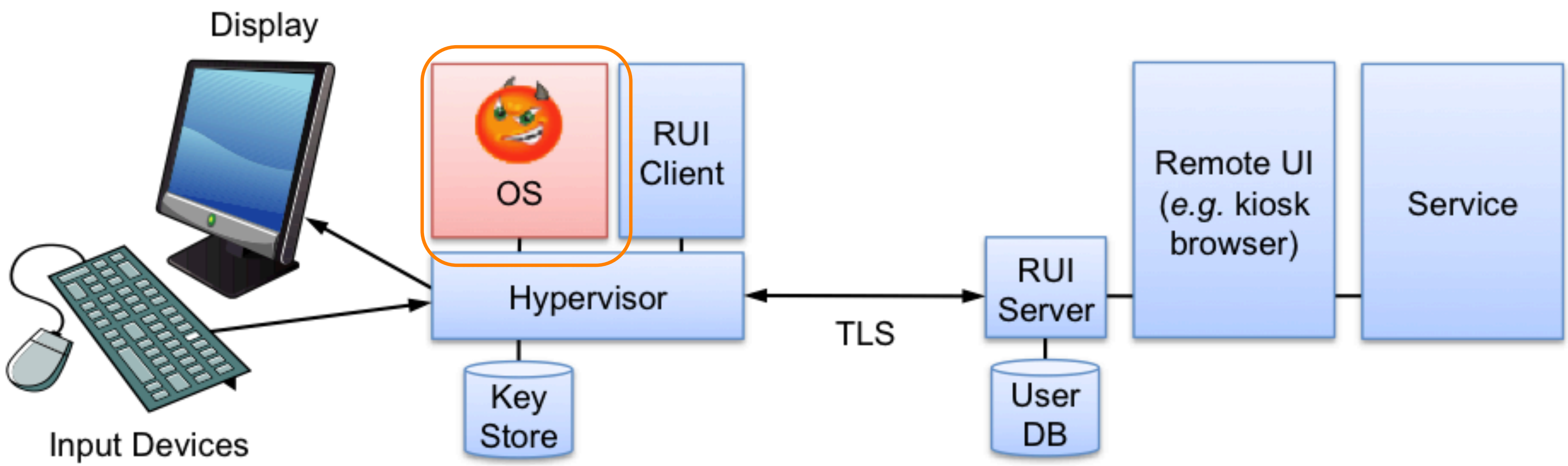
Malware has no capability to observe what's displayed

Cloud Terminal Architecture



User interacts using physical hardware events mediated by hypervisor directly to RUI client

Cloud Terminal Architecture



Malware has no opportunity to influence interaction

Tackling *Transaction Generators*

- Desired properties:
  - Compatible w/ existing legacy OS's
    - They run in VMs controlled by hypervisor
  - Can run general web applications
    - Anything that remote site can render into VNC-style framebuffer protocol
  - No need to trust host OS
    - Hypervisor provides strong isolation
  - Small TCB: attestable via TPM
    - Working implementation: 22 KLOC

Architectural Elements?

- Abstractions:
  - Interactions via “dumb” *separate* terminal
- Placement of functionality:
  - Move rendering into controlled environment
  - Add trusted hypervisor w/ local secrets/smarts
  - Require interactions to come from physical hardware
  - Use E2E principle to leverage untrustworthy code
- State:
  - Isolated to trusted component
- Naming:
  - Use existing PKI system + TPM

Imprinting

Device Authentication: IOT

For IOT device + home controller, want secure, impermanent associations.

Impermanent: so you can sell your device but a thief cannot.

Resurrecting Duckling

Imprinting on Mother:

Device shares key on 1st contact with controller

Metempsychosis:

Upon death, soul progresses to a new body

Reverse metempsychosis:

Upon death, new soul can enter the body

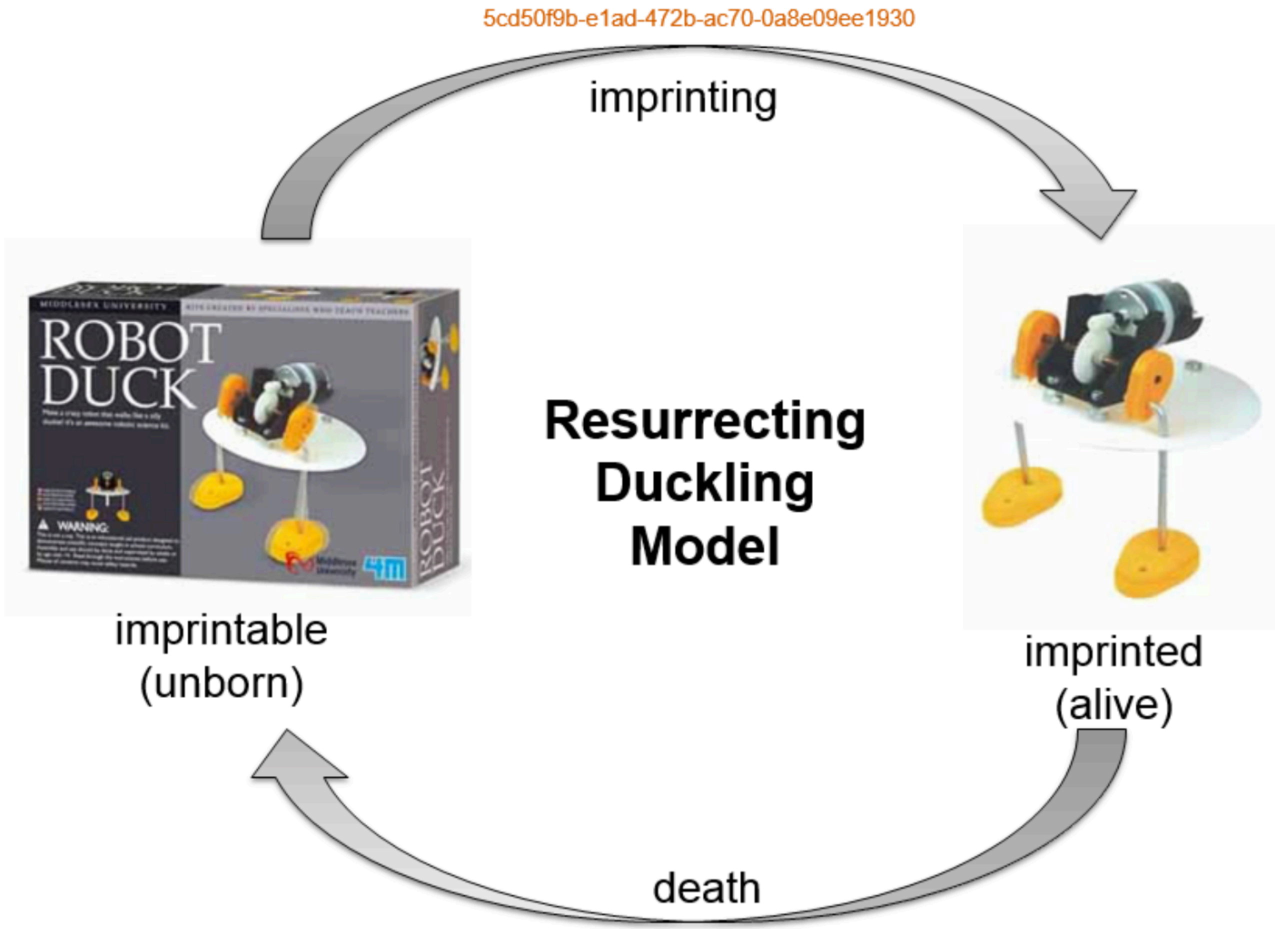
Resistance to assassination:

Only mother can kill her ducklings

Escrowed seppuku:

Manufacturer can kill too

Thief can't "kill" device
⇒ no utility for anyone who buys it from them



1. **Two state principal** – the ducking can be in one of 2 states; imprintable and imprinted. In the imprintable state, anyone can claim to be the duckling's mother. In the imprinted state, the duckling only obeys its mother.
2. **Imprinting principal** – imprinting happens when the mother duck sends an imprinting key to the duckling. This must be done over a channel that protects confidentiality and integrity of the key.
3. **Death principal** – the transition from imprinted to imprintable can only occur in specific circumstances defined by the model:
   - death by order of the mother duck (default)
   - death after a predetermined interval
   - death after the completion of a specific transaction
4. **Assassination principal** – The duckling must be constructed in a way that it is unfeasible for an attacker to force it into the imprintable state by means other than those stated in the death principal.

https://www.citrix.com/blogs/2015/04/20/resurrecting-duckling-a-model-for-securing-iot-devices/

Imprinting in Other Contexts

- What is SSH's PKI model?
  - It doesn't have one: *Leap-of-Faith*
- Pros:
  - **Ease of deployment**
- Cons:
  - Security properties require users to *non-satisfice*

```
The authenticity of host 'diablo.icir.org (192.150.187.59)'
 can't be established.
ECDSA key fingerprint is SHA256:uvJWTjlM5c74D5gp62GMeCk2ccB
ILukf91za1S2zl8k.
Are you sure you want to continue connecting (yes/no)?
```

  - No revocation model
  - Disaster if attacker gets there first

Persistent Ungrounded Identity

- Idea: systems generate (unanchored!) public key and consistently include it w/ (signed) messages
  - Provides recipient a lever for "*this is the same entity I talked with previously*" …
  - … even though actual identity ("persona") not known

"Assurance through continuity"

Persistent Ungrounded Identity

- Idea: systems generate (unanchored!) public key and consistently include it w/ (signed) messages
  - Provides recipient a lever for "*this is the same entity I talked with previously*" …
  - … even though actual identity ("persona") not known
- E.g.: consistently sign your email/texts
  - Recipient can associate reputation w/ each persona, use them for whitelisting
  - User can migrate persona to additional systems
- E.g.: use for SBGP instead of a PKI
  - Game theory result: deployment gains a *network effect*

Persistent Ungrounded Identity

- Idea: systems generate (unanchored!) public key and consistently include it w/ (signed) messages
  - Provides recipient a lever for “*this is the same entity I talked with previously*”
  - … eve … own
- E.g.: co…
  - Recipient can associate reputation w/ each persona, use them for whitelisting
  - User can migrate persona to additional systems
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Issues?
Key compromise is a **disaster**
No apparent handle for **revocation**

Multi-Party Identities

Cashier-as-a-Service (CAAS)

Abstract Ecommerce workflow:

1. Shopper surfs Merchant's site

2. Shopper sends over …`/place_order.html`
3. Merchant sends back redir. to `CAAS.com`

4. Shopper interacts with CAAS
5. CAAS interacts with Merchant

6. CAAS redirects shopper back to Merchant

CAAS Attack #1 ?

S⟶M: `place_order.html`

[*M inserts ID and price into database; status=**PENDING***]

M⟶S⟶C: `get_payment?orderID=`*X*`&price=`*Y*

[*C records payment info, generates transaction # **T***]

C⟶S⟶M: `finish?transID=`*T*

[*M contacts C for identifer **X** associated w/ **T***]

[*M retrieves orderID=**X** from database;*

*if order status = **PENDING** → mark as **PAID**; ship X*]

Note: we view Merchant and Cashier as trustworthy. The *Shopper*, OTOH …

CAAS Attack #1 !

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CAAS Scheme #2 ?

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[*C records payment info, generates transaction #* ***T***]

C⟶S⟶M: `finish?transID=`*T*

[*M contacts C for identifer* ***X*** *associated w/* ***T***]

[*M retrieves orderID=****X*** *from database;*

if order status = ***PENDING*** *→ mark as* ***PAID****; ship X*]

CAAS Attack #2 ?

S⟶M: `place_order.html`

[*M inserts ID and price into database; status=**PENDING***]

M⟶S⟶C: `get_payment?SIGN`$_M$`(ID=`*X*`,price=`*Y*`)`

[*C verifies signature; records payment info, generates # **T***]

C⟶S⟶M: `finish?SIGN`$_C$`(ID=`*X*`,price=`*Y*`,`**PAID**`)`

[*M verifies signature and **PAID** is indicated*]

[*M retrieves orderID=**X** from database;*

*if order status = **PENDING** → mark as **PAID**; ship X*]

CAAS Attack #2 !

S⟶M: `place_order.html`

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[*M verifies signature and **PAID** is indicated*]

[*M retrieves orderID=**X** from database;*

if ord … *ship X*]

Shopper **colludes** with *another* merchant M' to get a signature on same identifier *X* for price *Y* … without having to ultimately pay

Fix for CAAS Attack #2

S⟶M: `place_order.html`

[*M inserts ID and price into database; status=**PENDING***]

M⟶S⟶C: `get_payment?`

$\texttt{SIGN}_{M}(\texttt{ID=}X\texttt{,price=}Y\texttt{,merch=}M)$

[*C verifies signature; records payment info, generates # **T***]

C⟶S⟶M: `finish?`

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[*M verifies signature and **PAID** is indicated, etc.*]

[*M retrieves orderID=**X** from database;*

*if order status = **PENDING** → mark as **PAID**; ship X*]

Better Fix for CAAS Attack #2

S⟶M: `place_order.html`

[*M inserts ID and price into databas*

Principle: always sign *all* the information that went into a decision

M⟶S⟶C: `get_payment?`

`SIGN`$_M$`(ID=`X`,price=`Y`,merch=`M`,shop=`S`)`

[*C verifies signature; records payment info, generates # **T***]

C⟶S⟶M: `finish?`

`SIGN`$_C$`(ID=`X`,price=`Y`,merch=`M`,shop=`S`,`**PAID**`)`

[*M verifies signature and **PAID** is indicated, etc.*]

[*M retrieves orderID=**X** from database;*

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