Engineering Robust Server Software

Defense In Depth

Duke
UNIVERSITY

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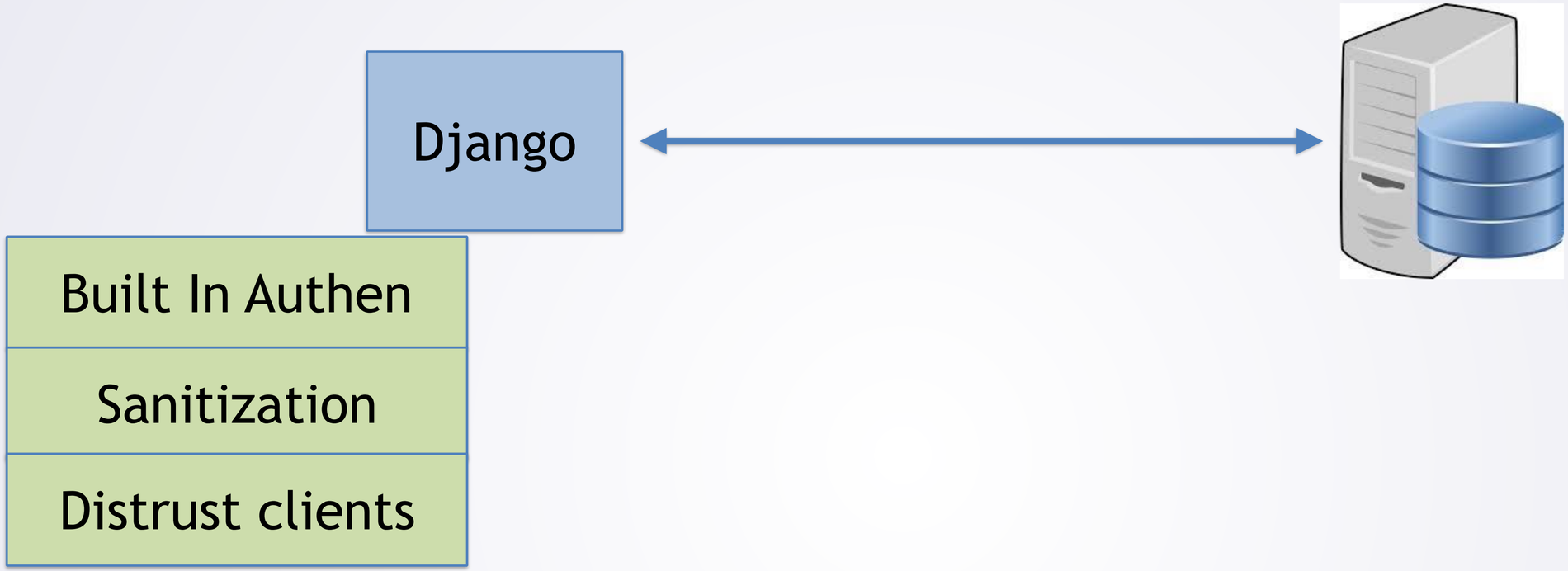

- Use all the best practices you know

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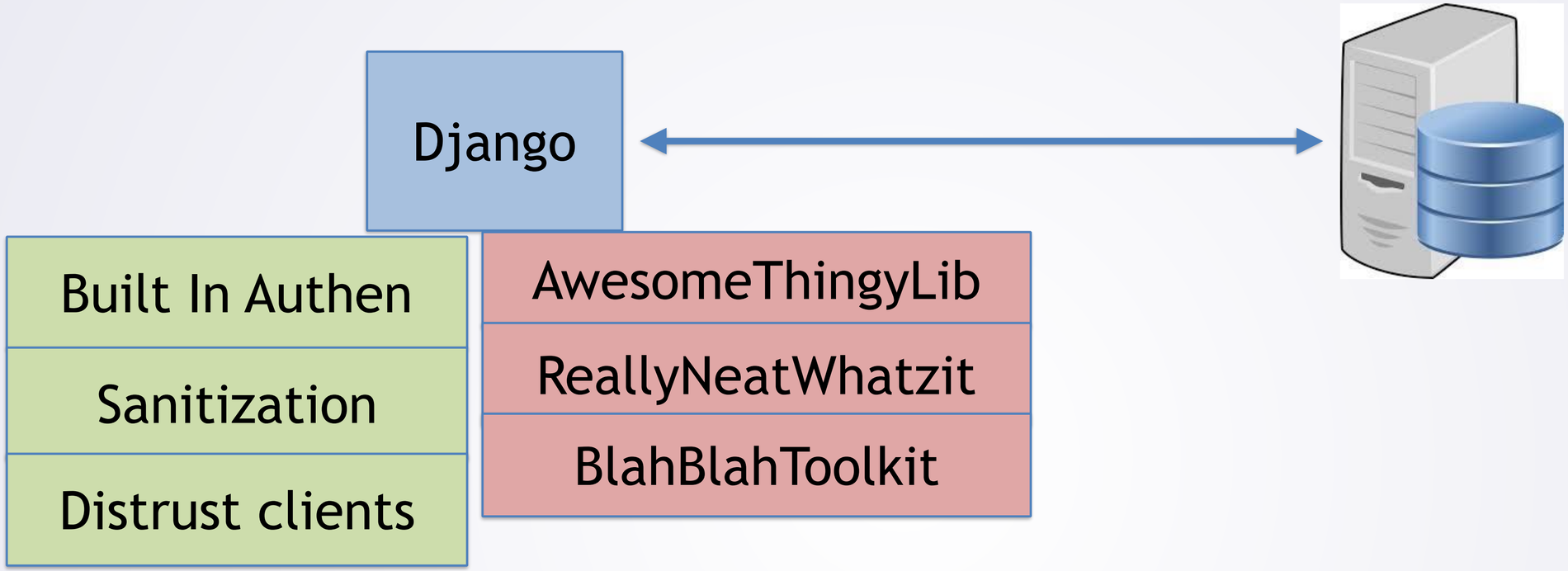

- ...But also lots of things you didn't write
  - Adds a lot of complexity...

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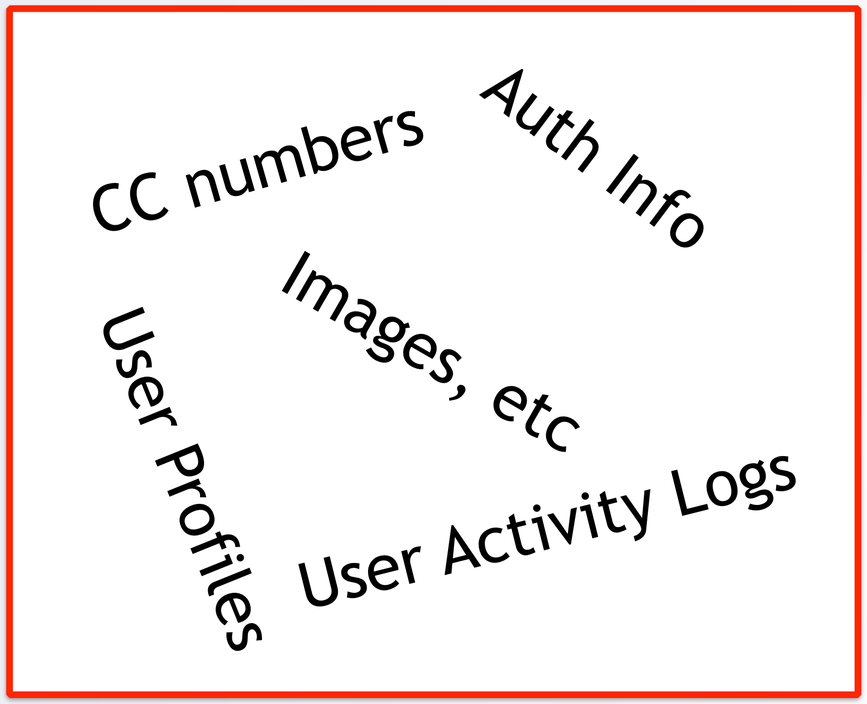
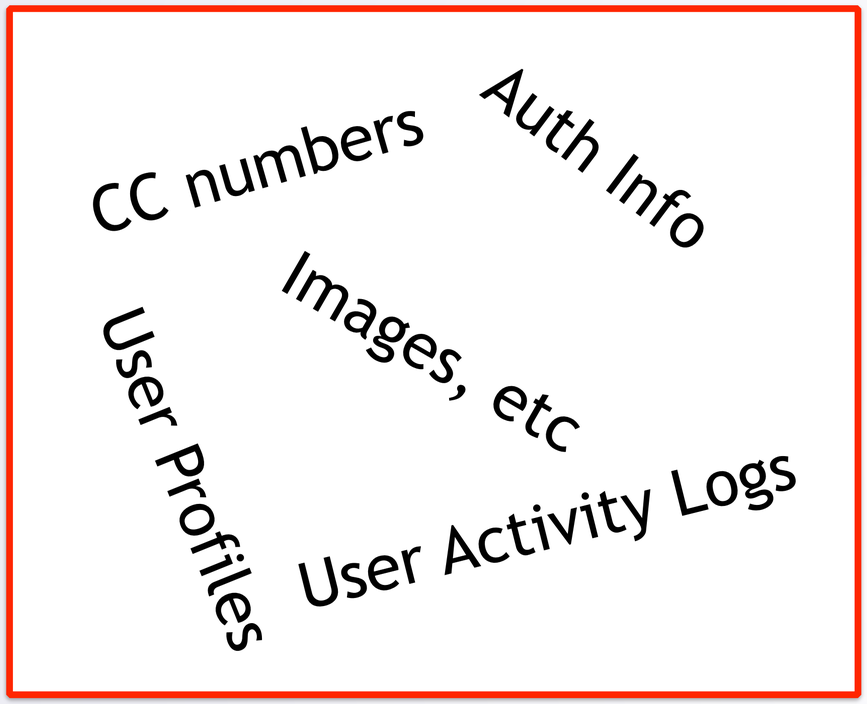
- Oh plus what about the other developers on your team?

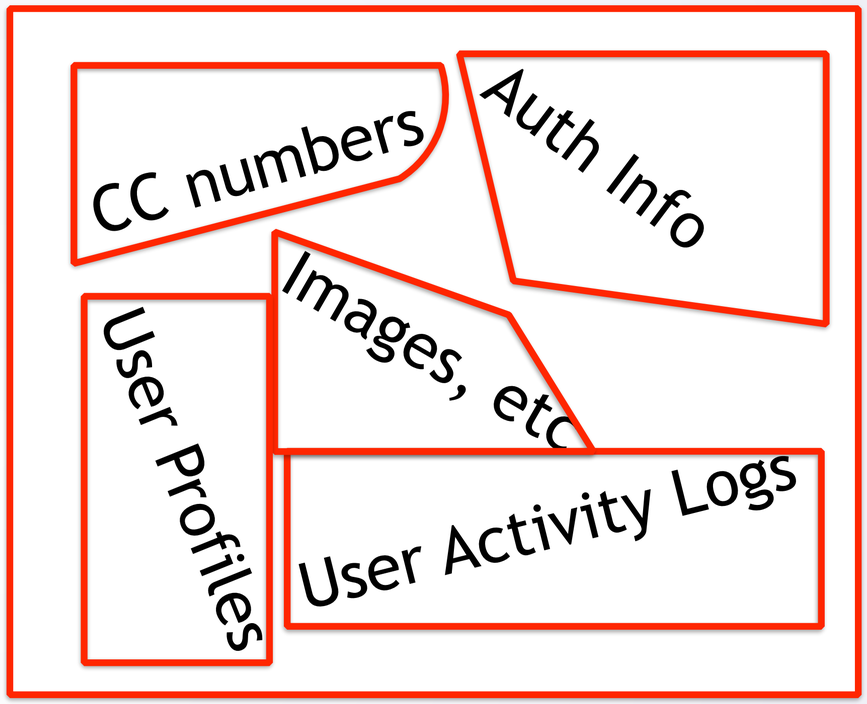
What Happens If Something Goes Wrong?



- Suppose a vulnerability exists: what is the damage?

Defense In Depth





- Idea: Assume one layer of security might fail
  - Multiple layers of security
  - Minimize damage if one layer is compromised

Example of This That We Have Seen?

- What have we already seen that is an example of mitigating damage if compromised?
  - **A**: nop slide
  - **B**: CSRF token
  - **C**: Diffie-Hellman Key Exchange
  - **D**: Salt and hash passwords

Famous Example of NOT Defense In Depth

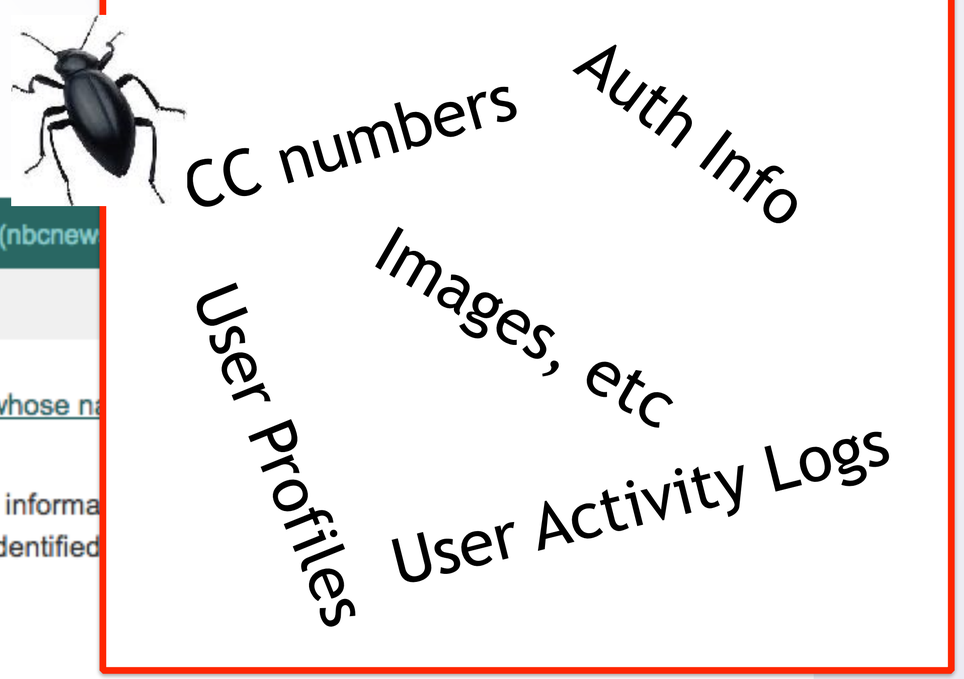
- Equifax got hacked
  - Bug in web library they were using
  - Many users' personal data (SSNs, etc) stolen
- Why/how?
- What should they have done?

Equifax Identifies Additional 2.4 Million Customers Hit By Data Breach (nbcnew

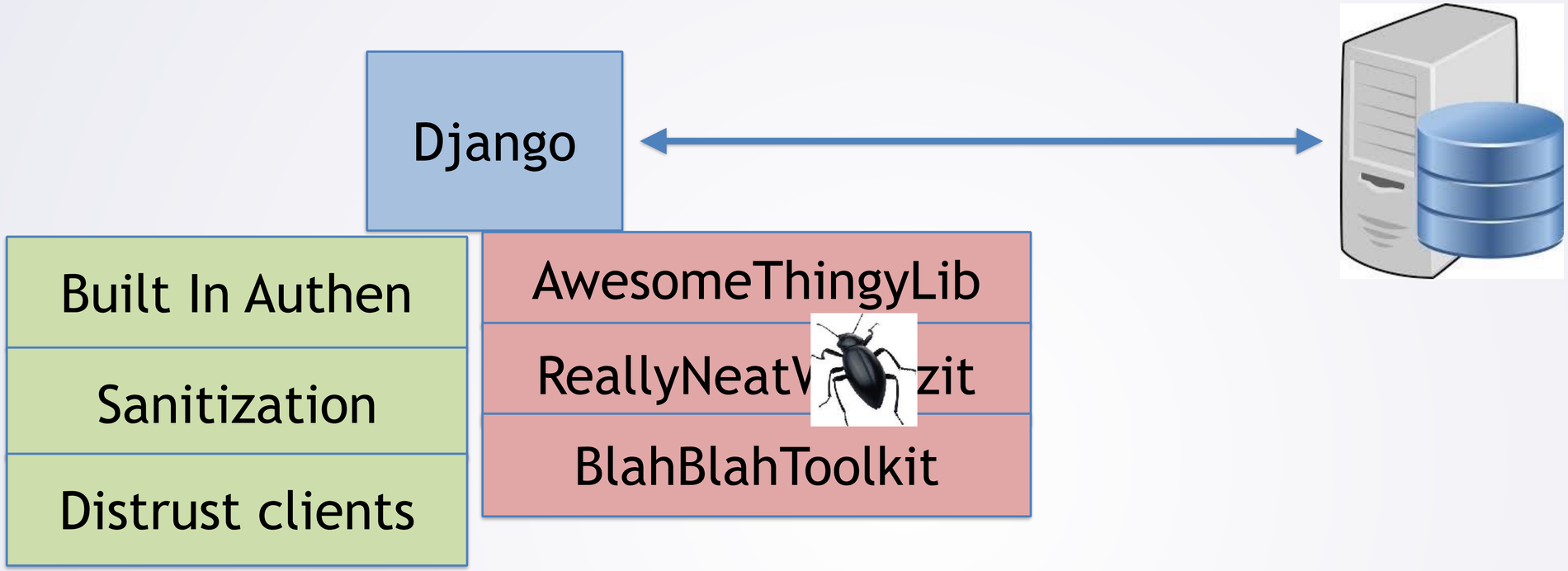
Posted by msmash on Thursday March 01, 2018 @12:45PM from the gift-that-keeps-giving dept.

Credit score giant Equifax said on Thursday it had identified another 2.4 million U.S. consumers whose na
a data breach last year that affected half the U.S. population. From a report:

> The company said it was able confirm the identities of U.S. consumers whose driver's license informa
> proprietary company records that the attackers did not steal. "Equifax will notify these newly identified
> protection and credit file monitoring services at no cost to them," the company said.



Vulnerability -> Access To All Things



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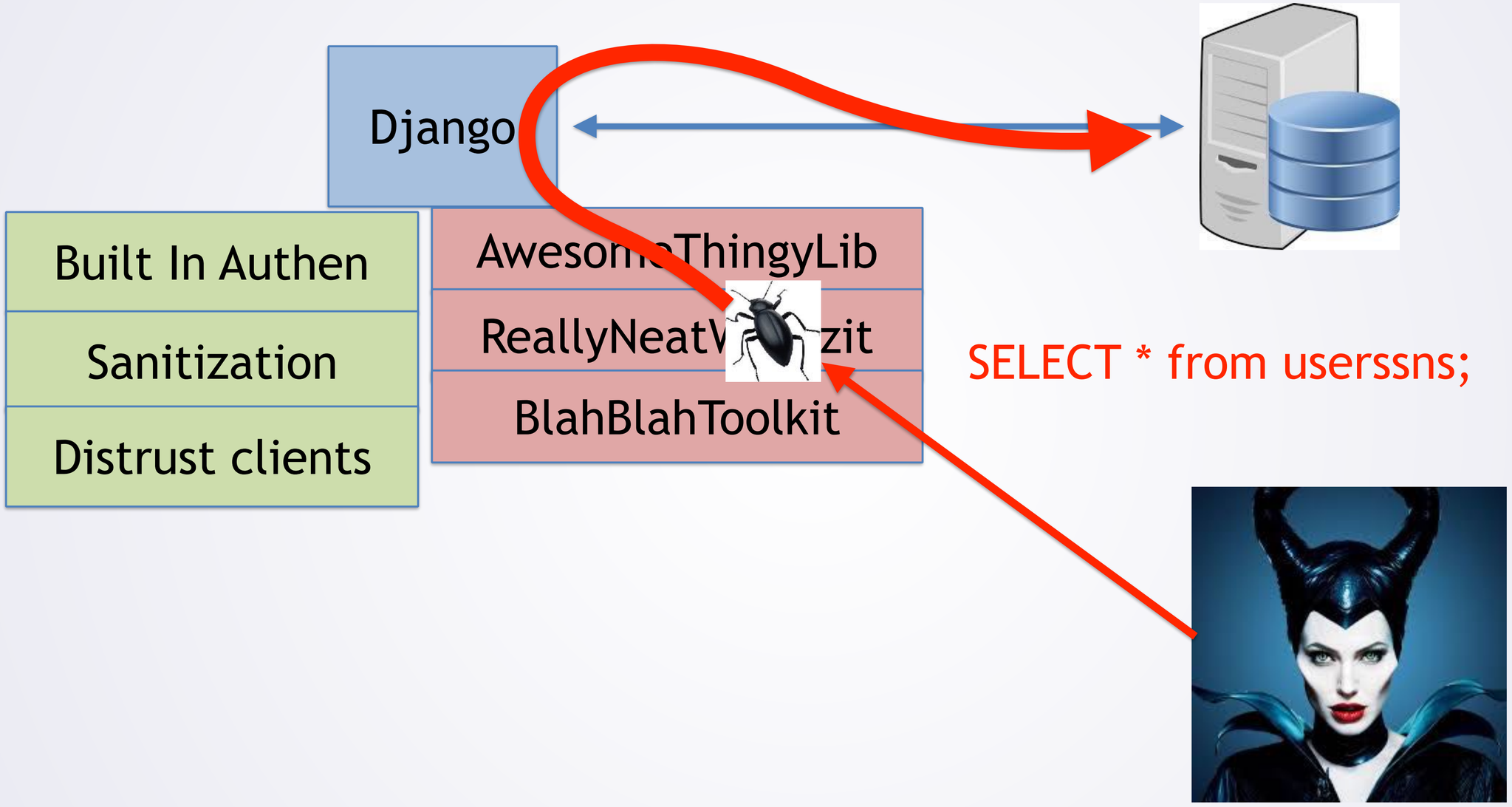
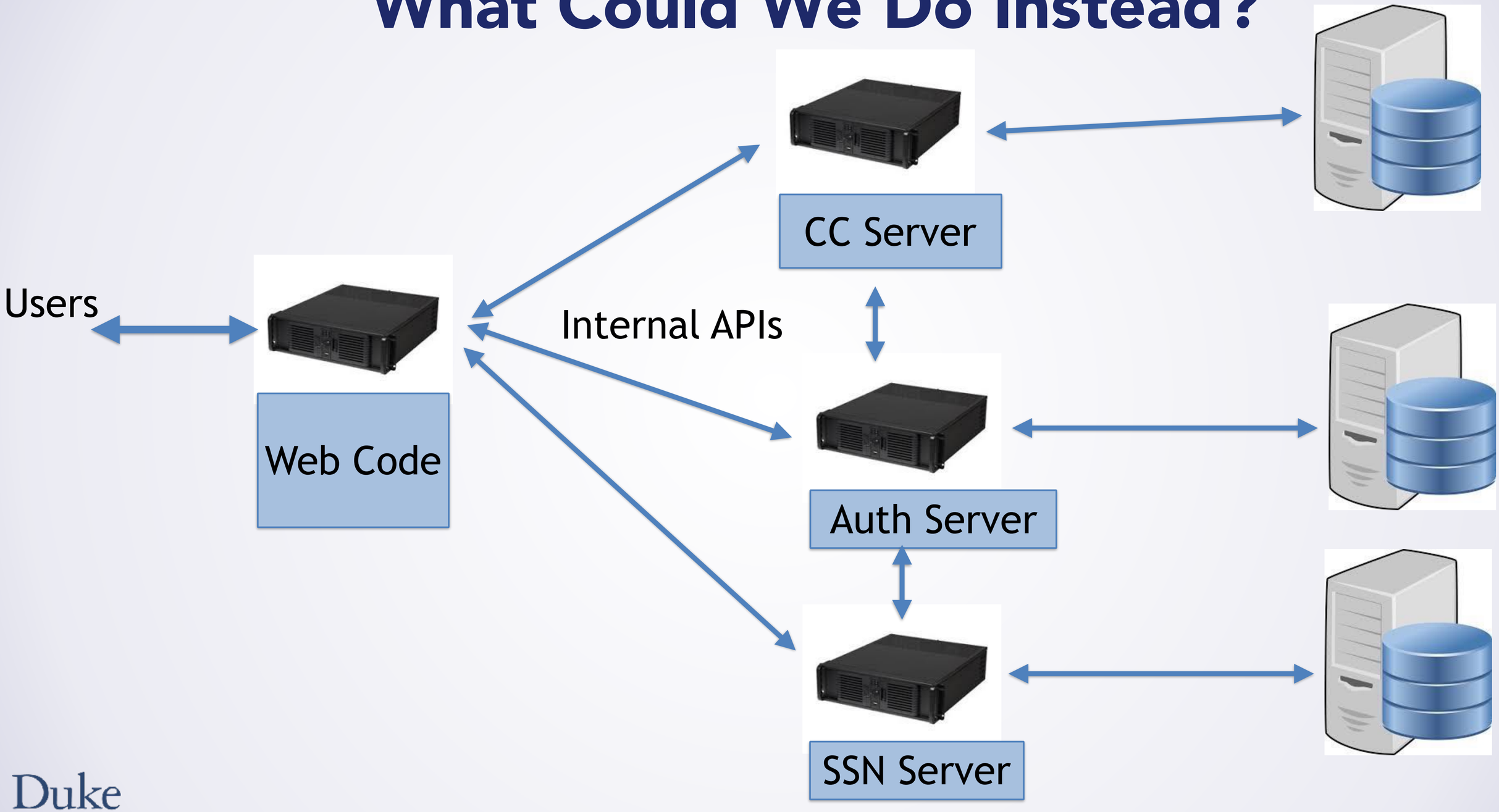


What Could We Do Instead?



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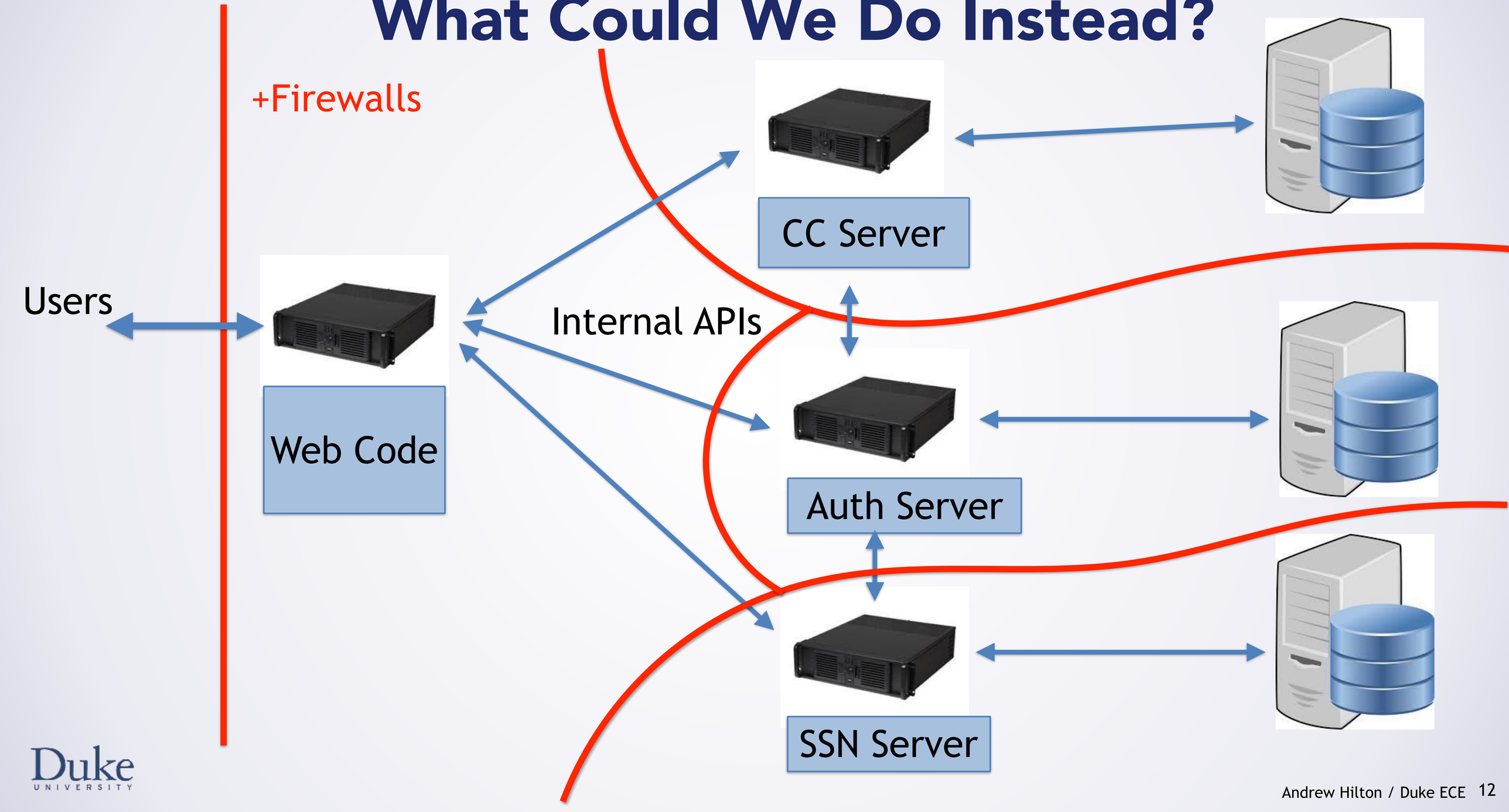
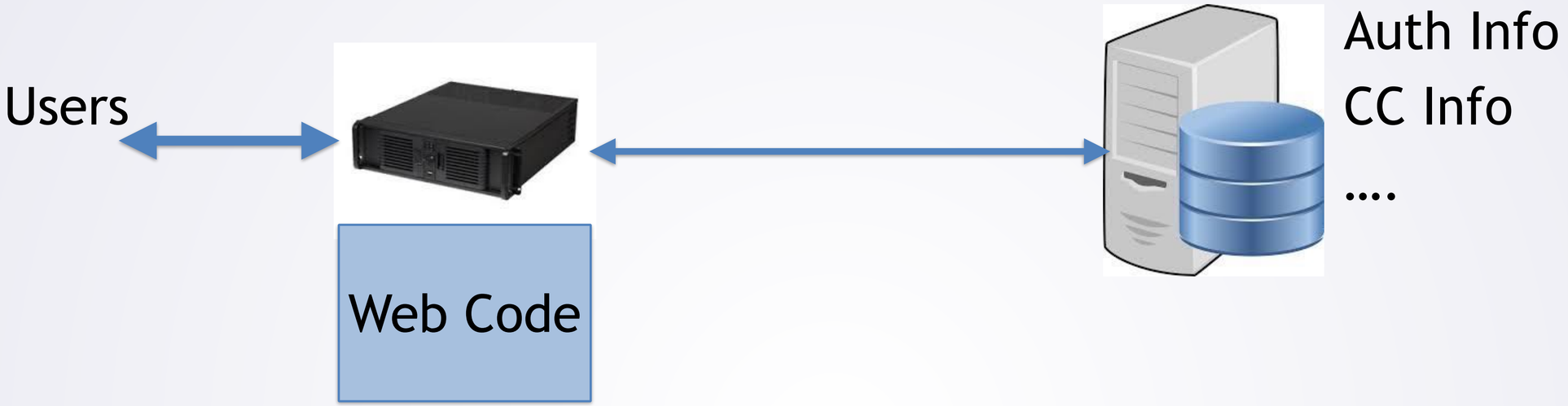


Contrast: Make a Purchase



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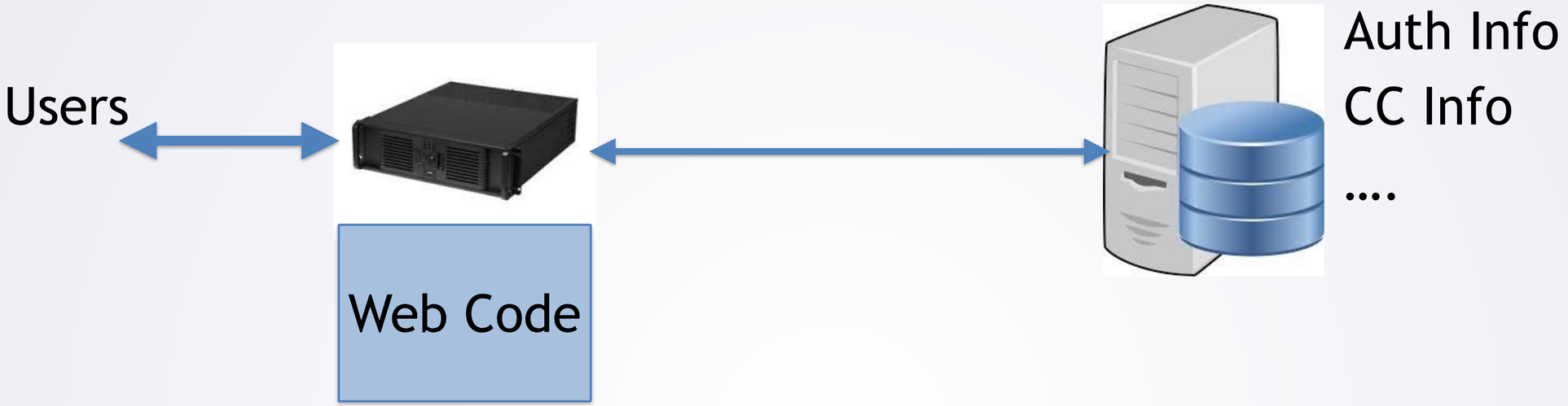
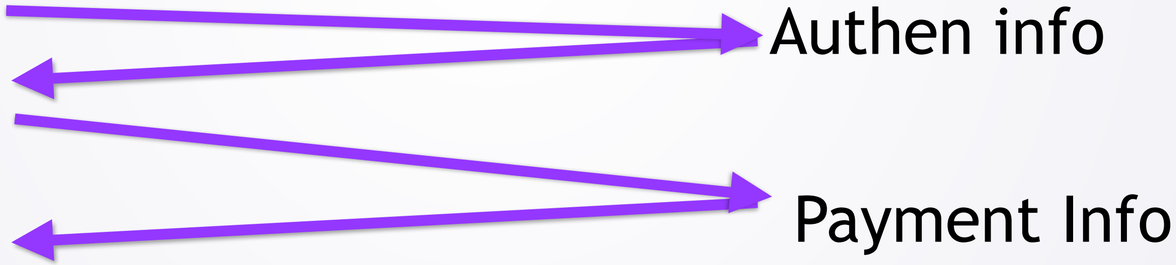


GET /selectPayment

(Payment page)



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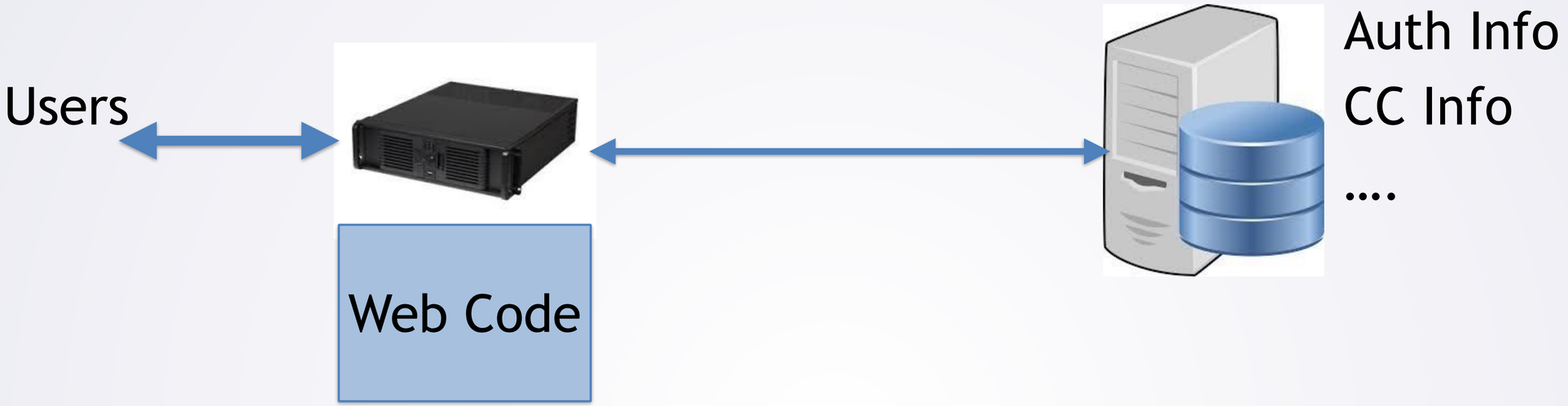


GET /selectPayment

Authen info

Payment Info

(Payment page)

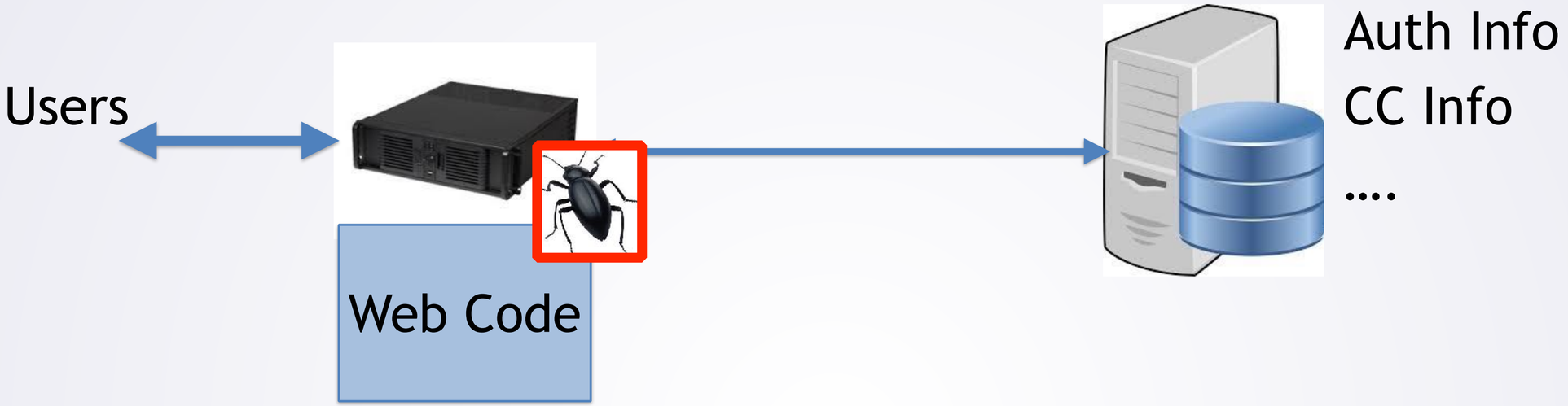
POST /makePayment

Authen info

Payment Info

To CC Processor

Contrast: Make a Purchase



GET /selectPayment

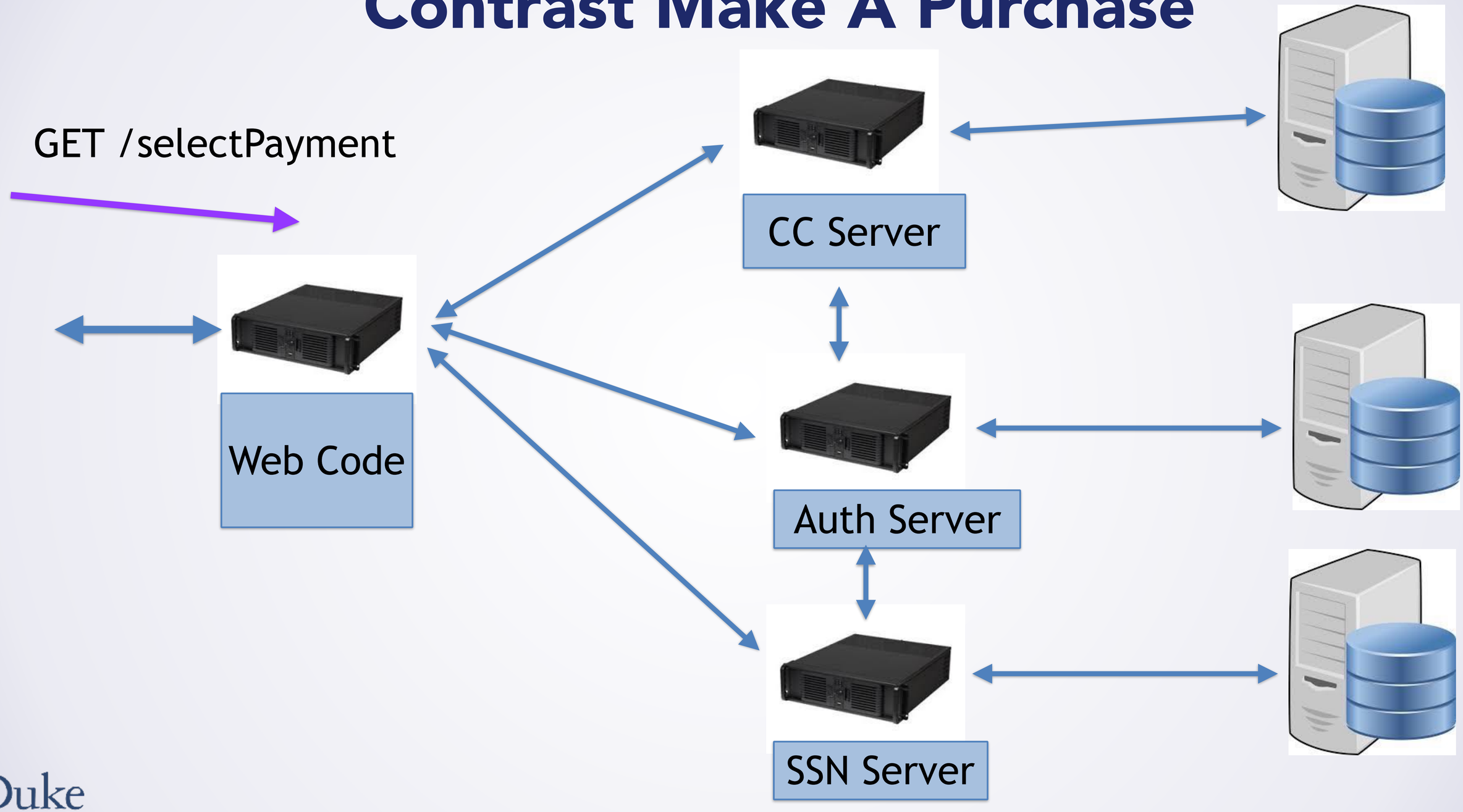
Authen info

Get all user's info

(all the info)

(everyone's
credit card #s
hashed pwds
SSNs…)

Contrast Make A Purchase



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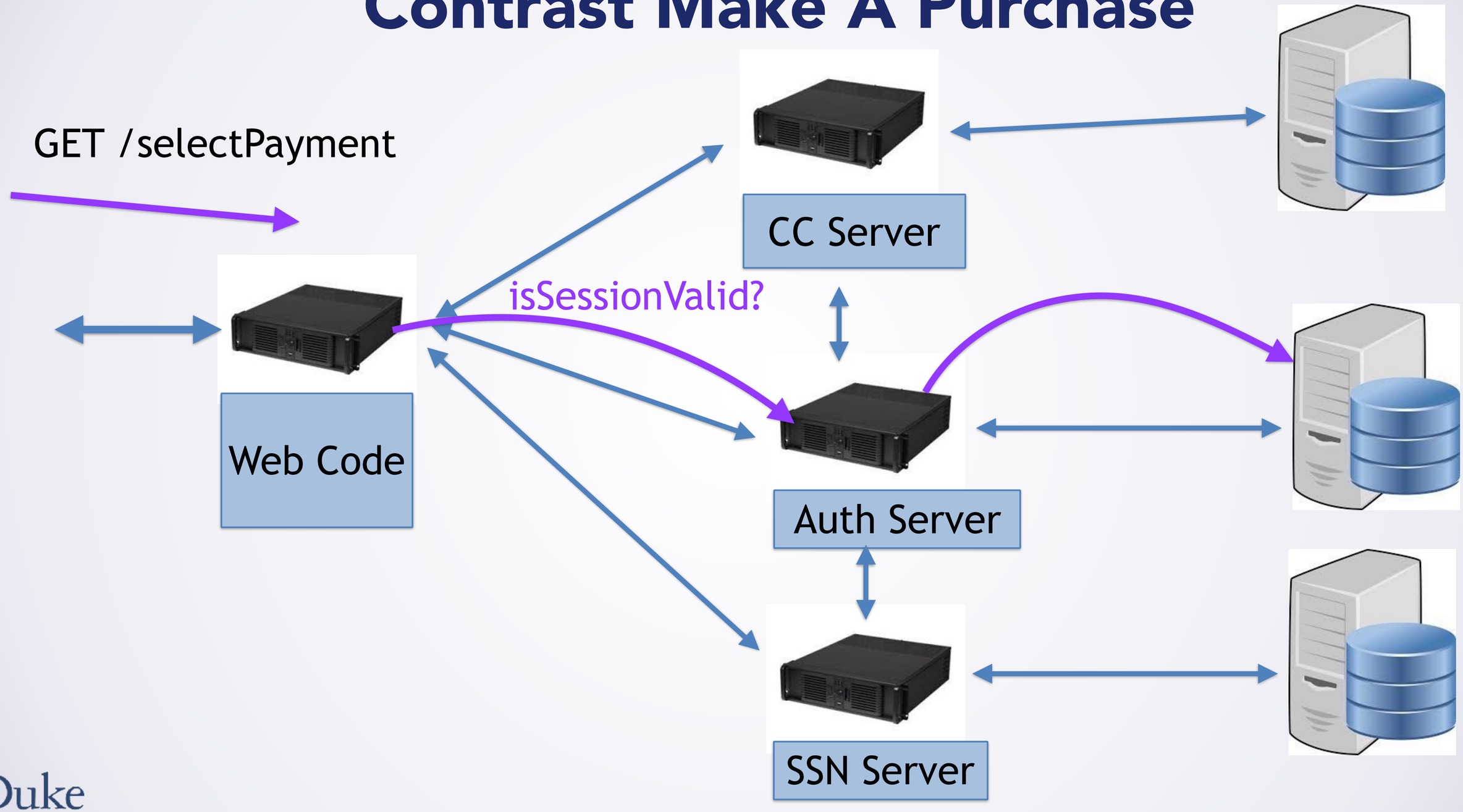

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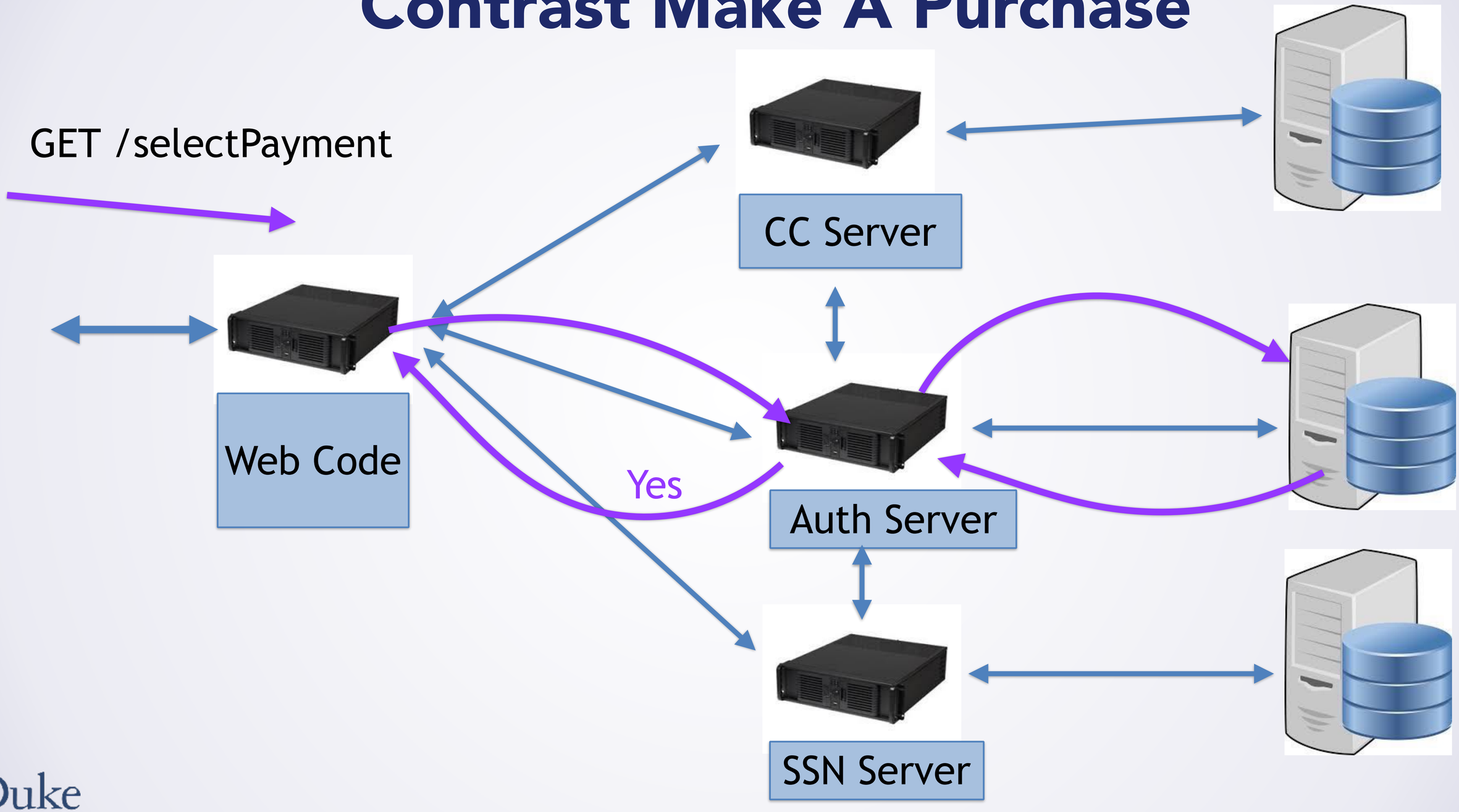

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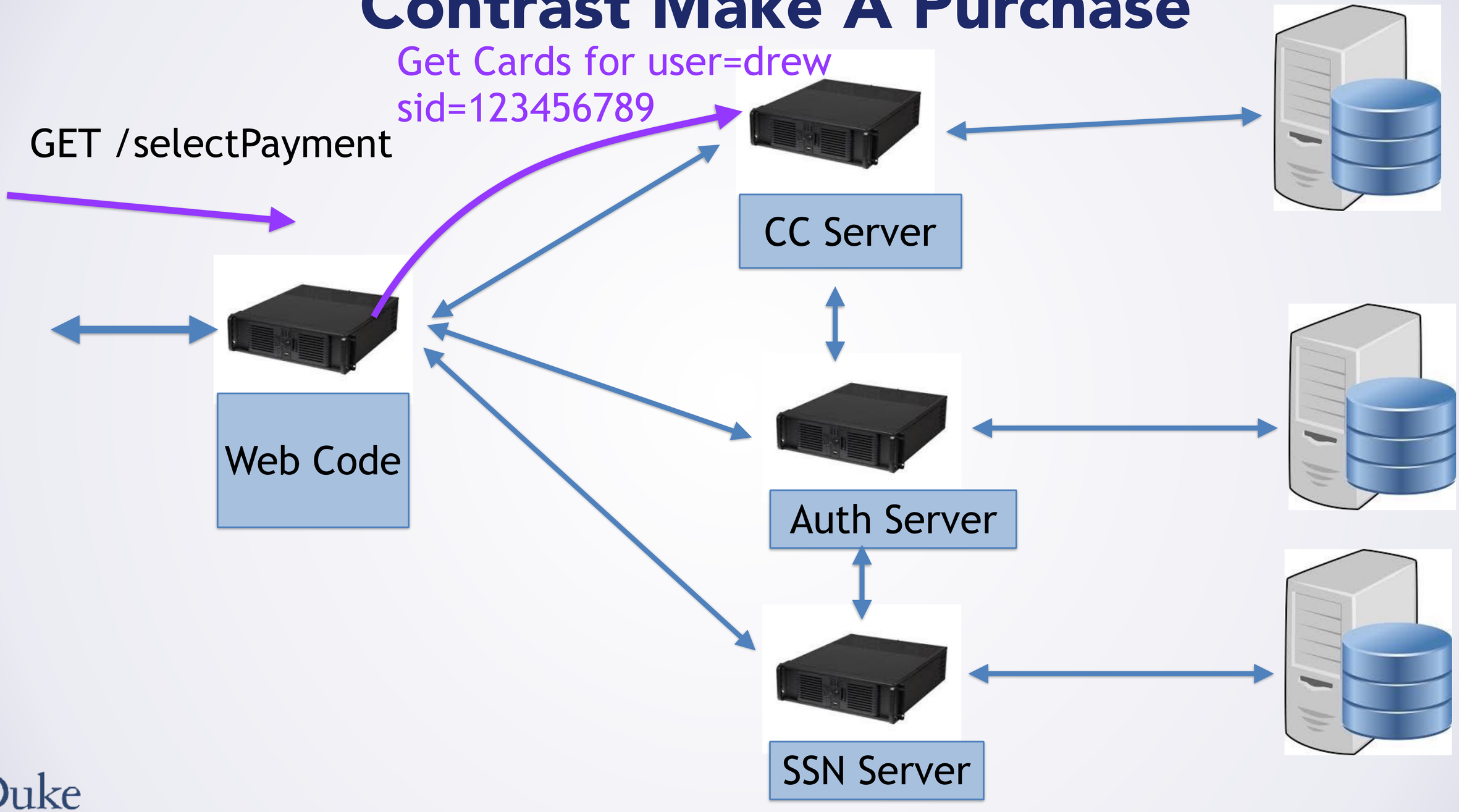

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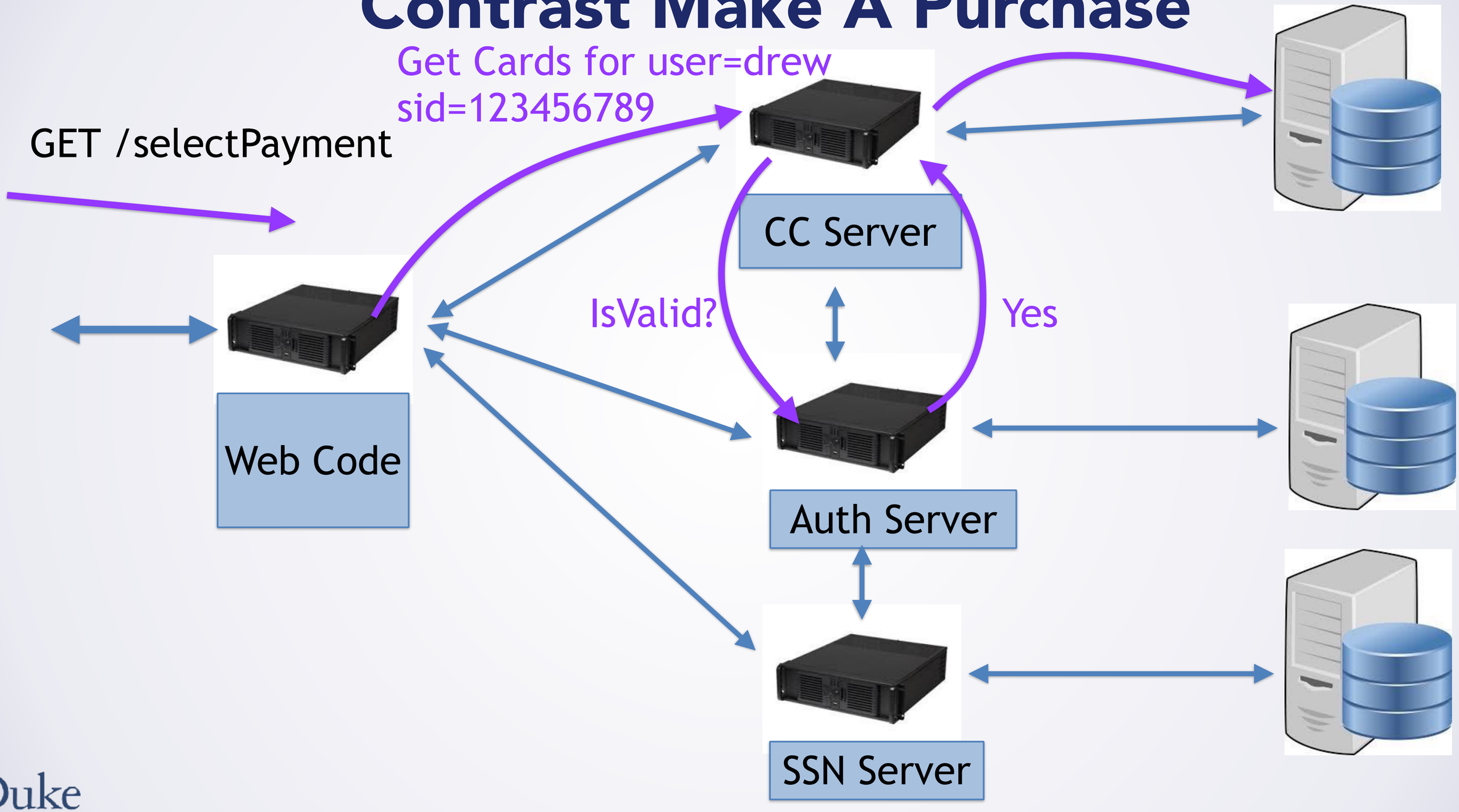

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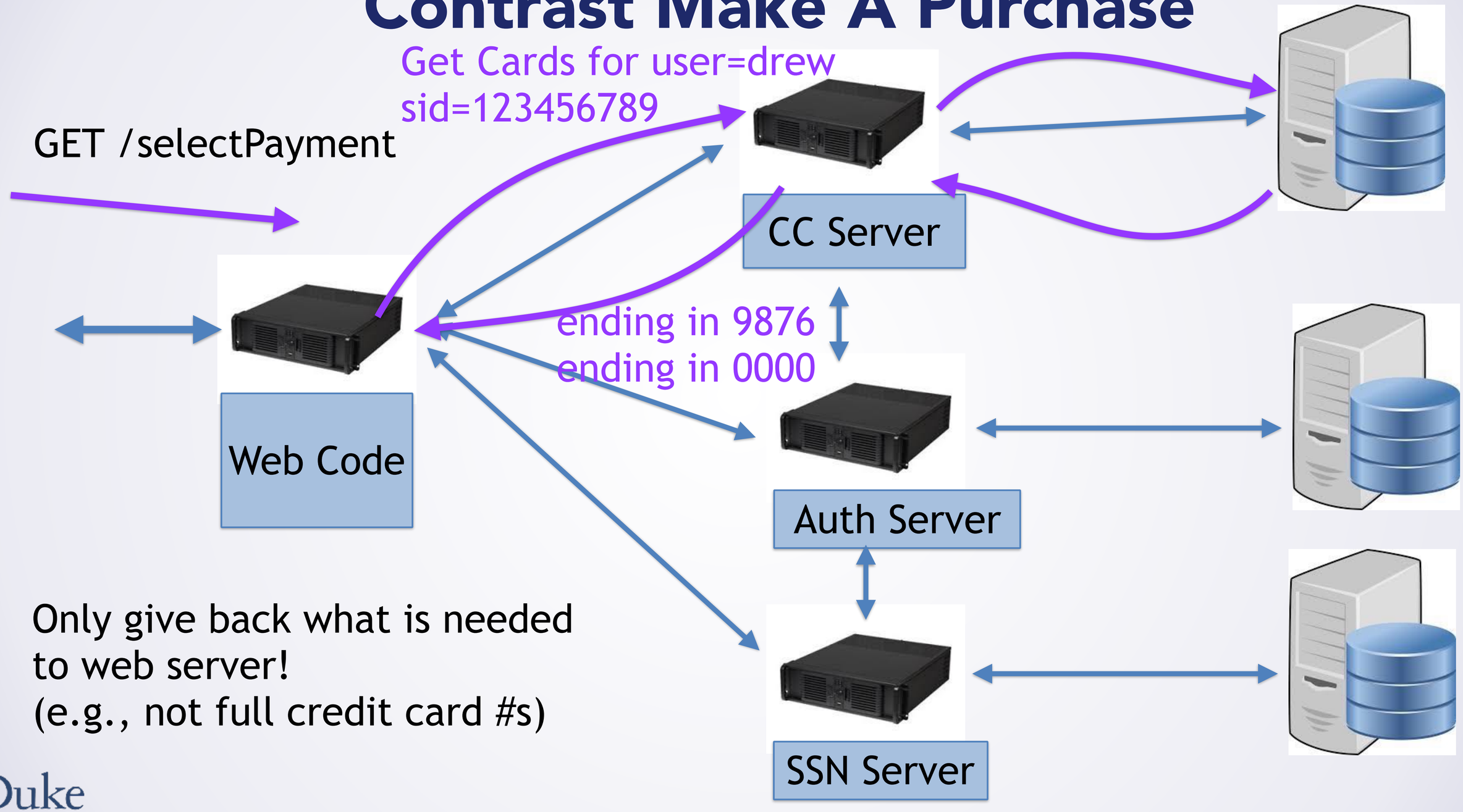
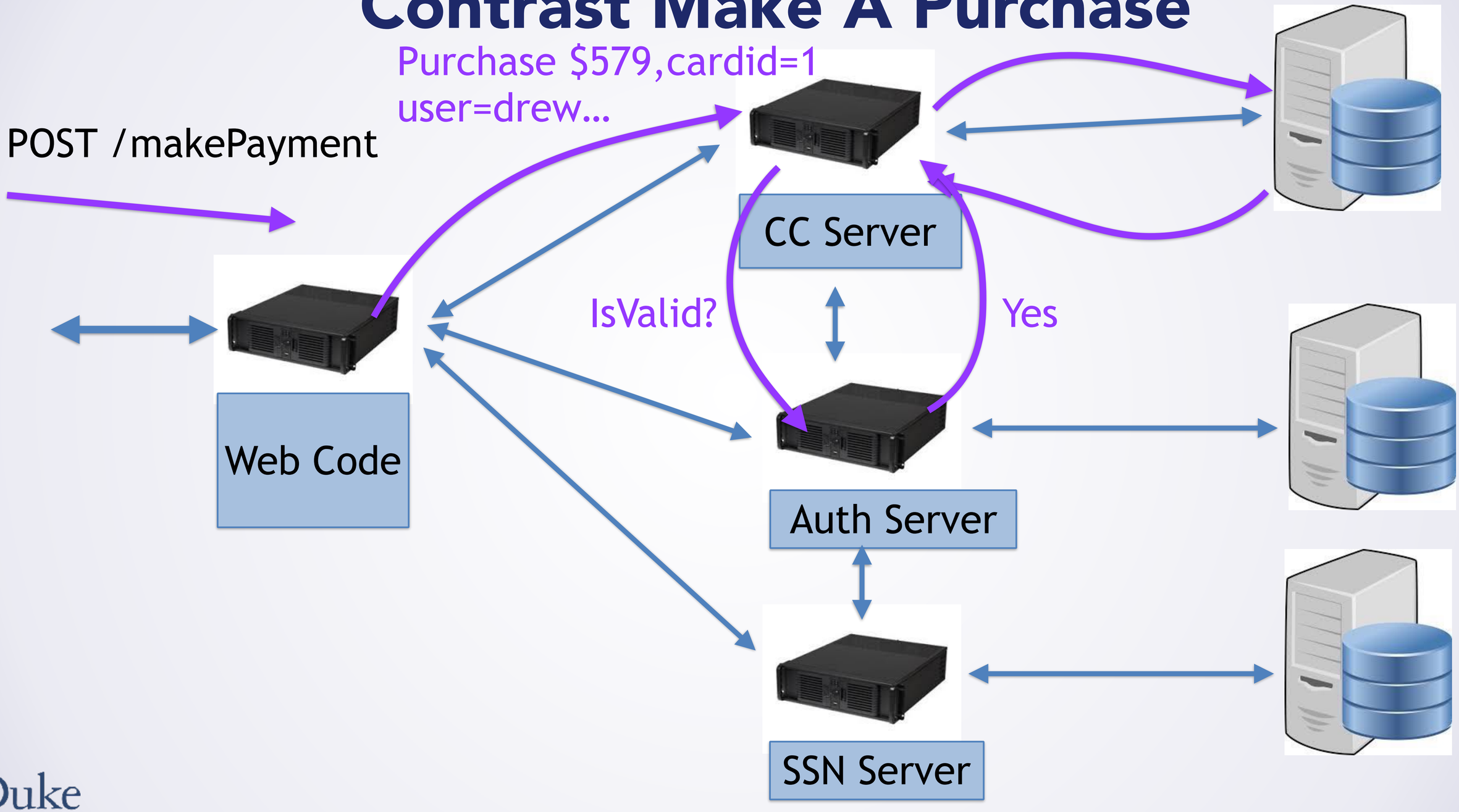


Only give back what is needed to web server!
(e.g., not full credit card #s)

Contrast Make A Purchase



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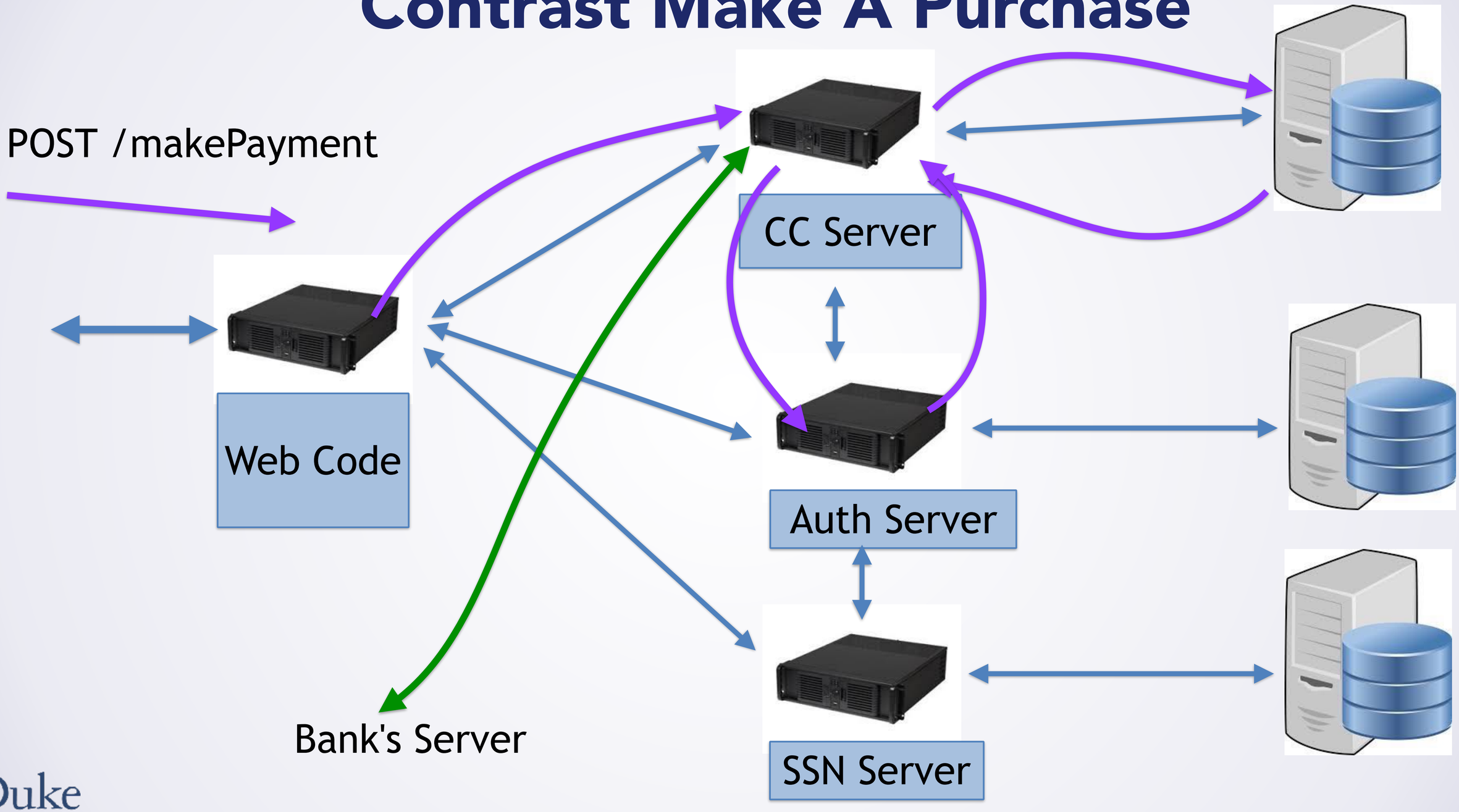

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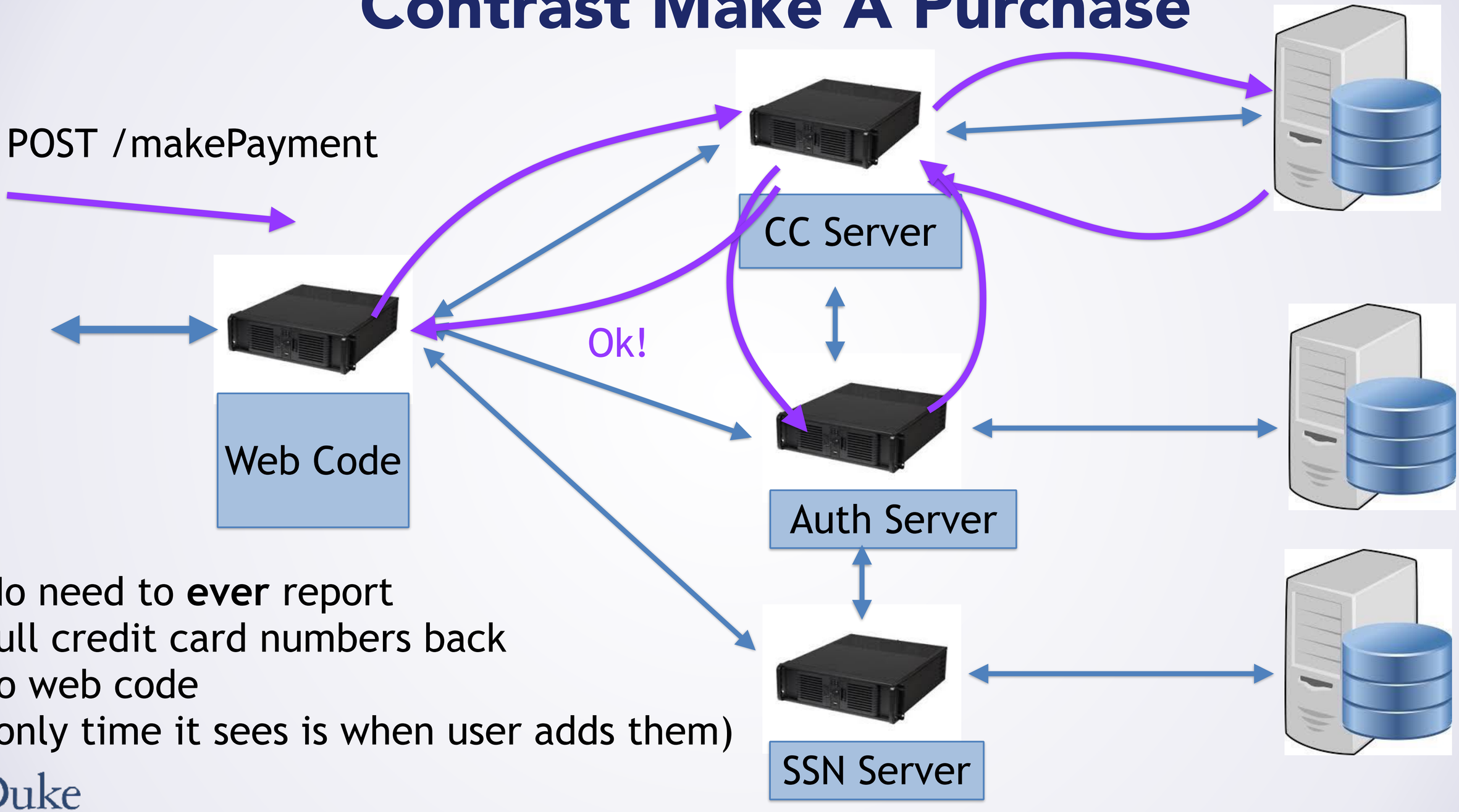
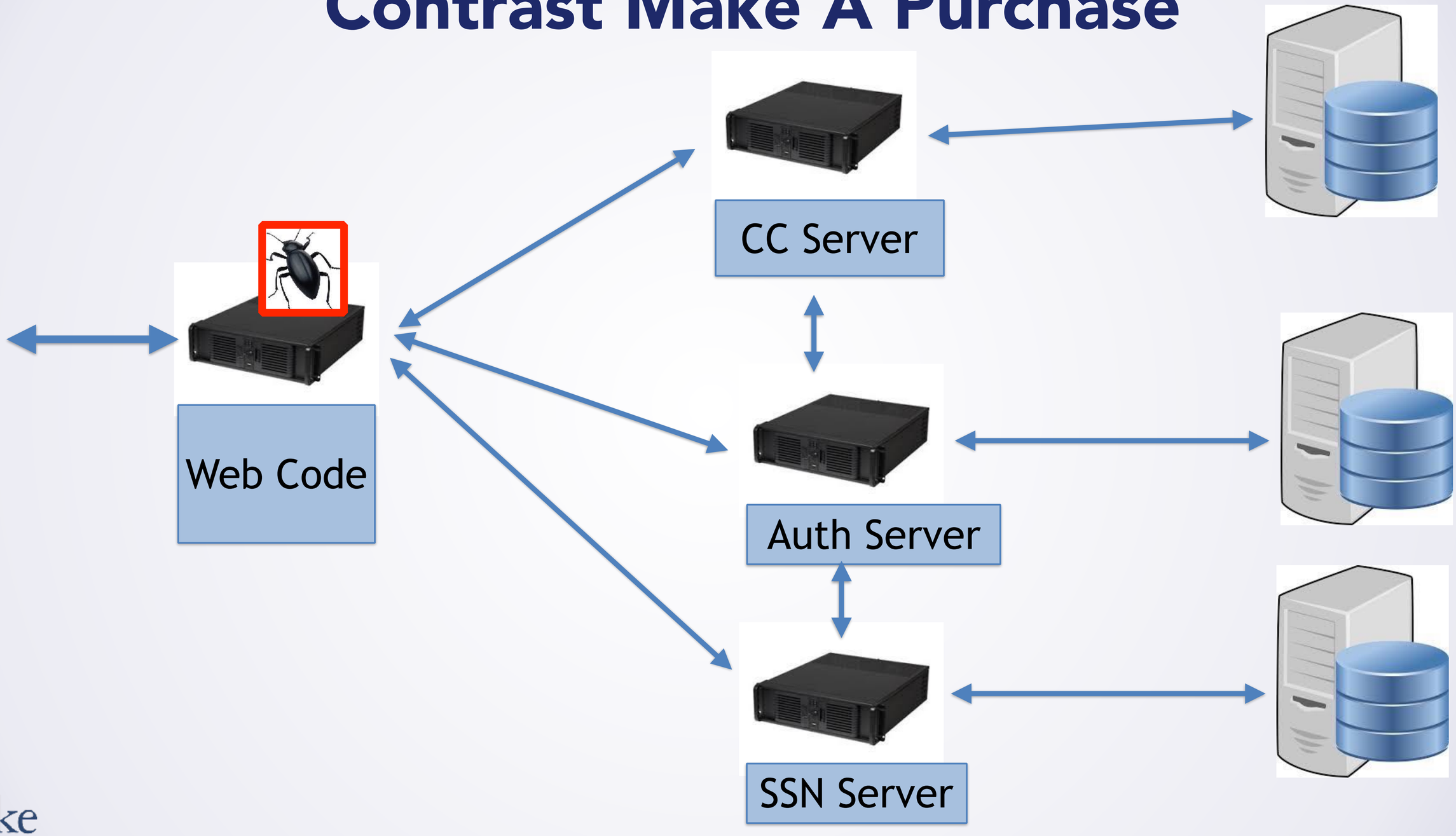


No need to **ever** report
full credit card numbers back
to web code
(only time it sees is when user adds them)

Contrast Make A Purchase



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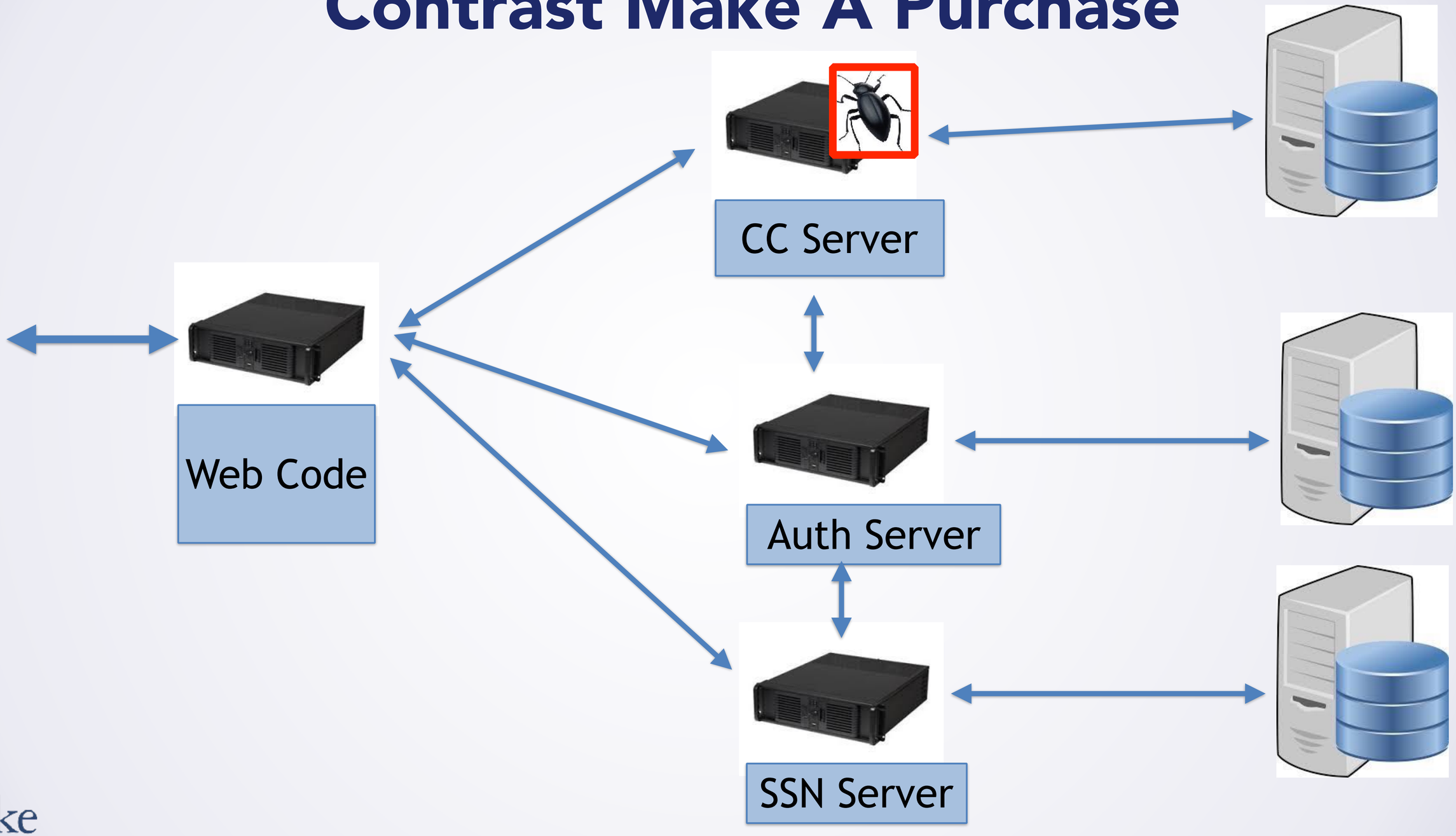

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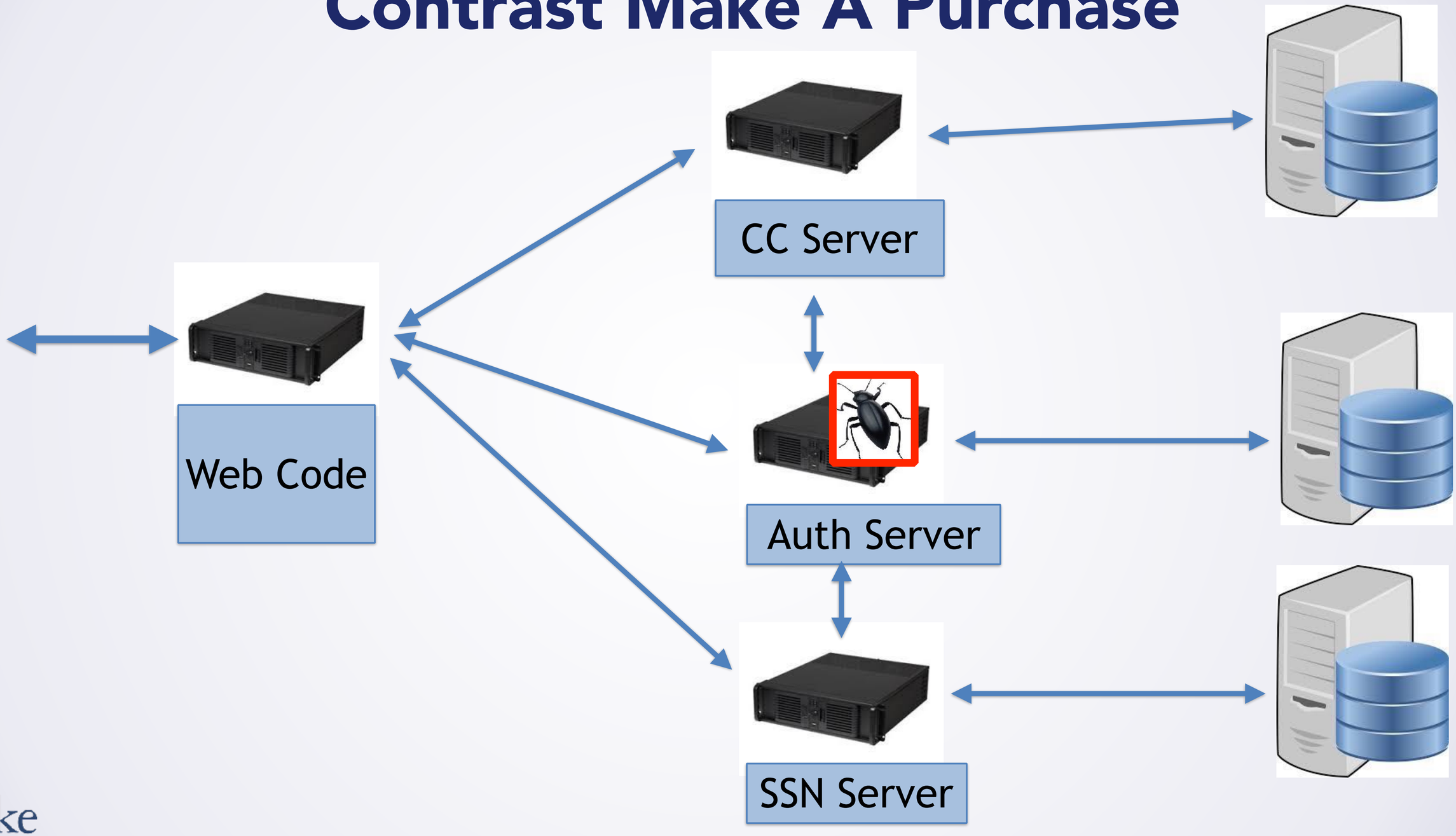

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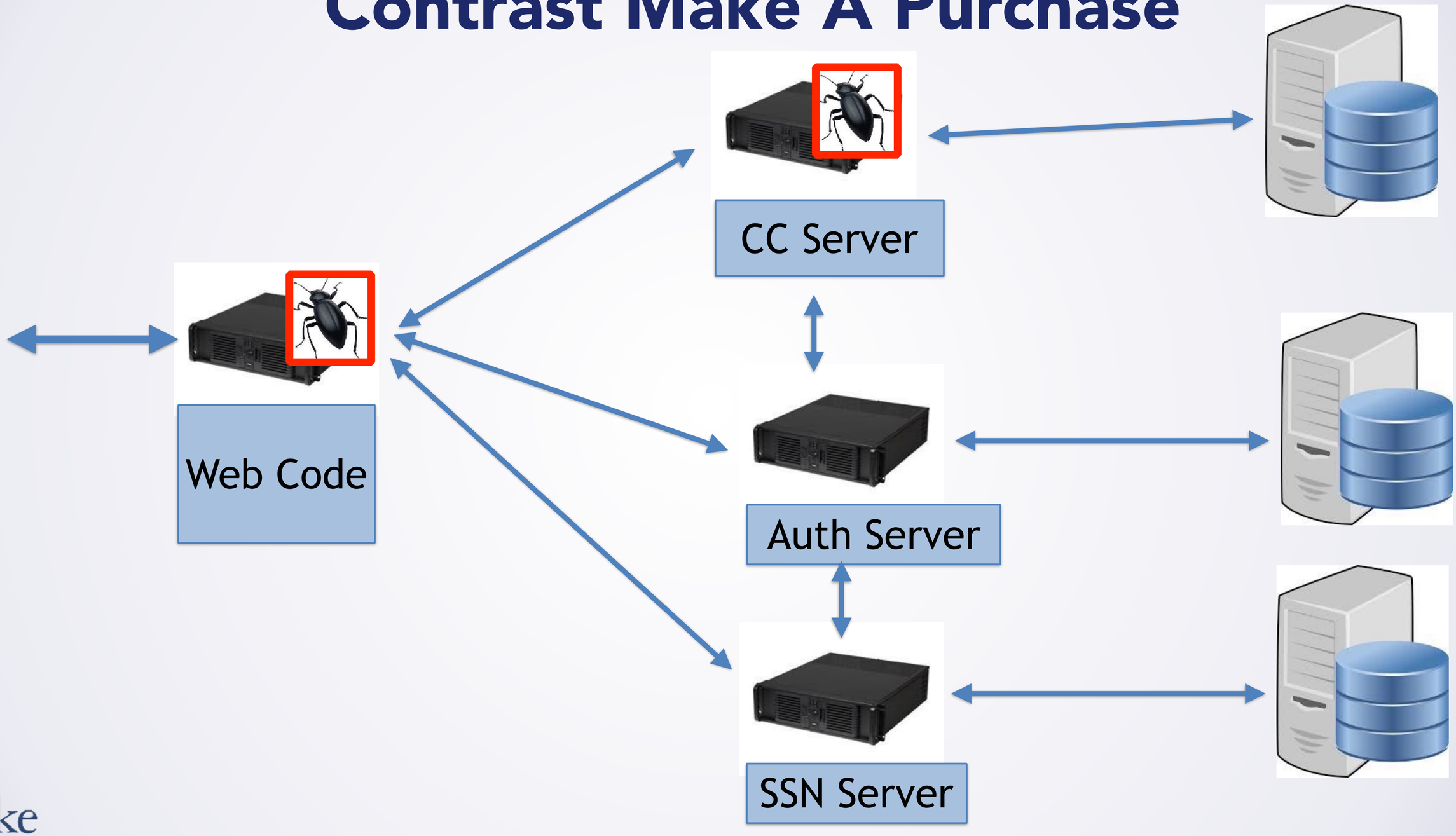
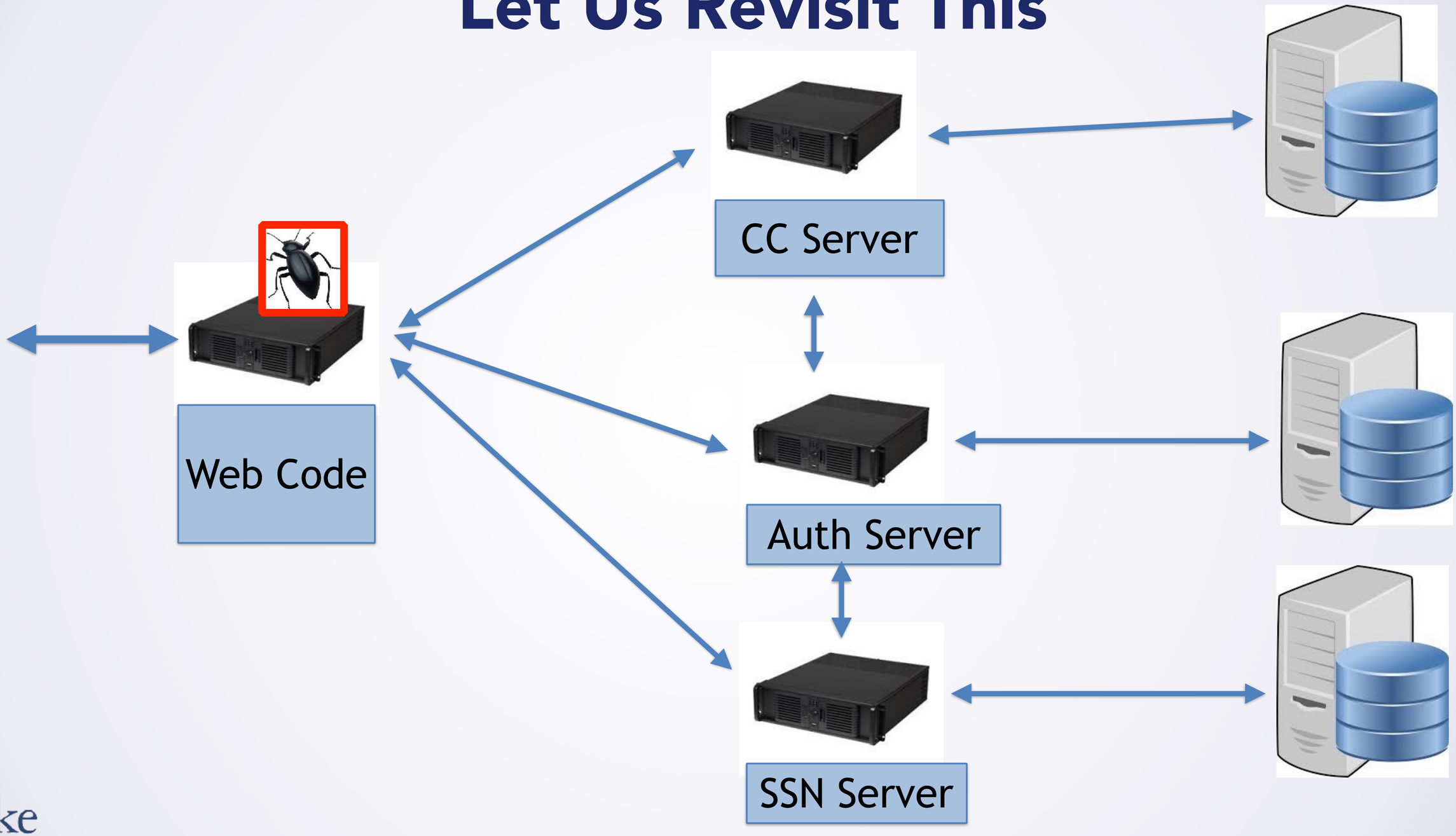


Let Us Revisit This



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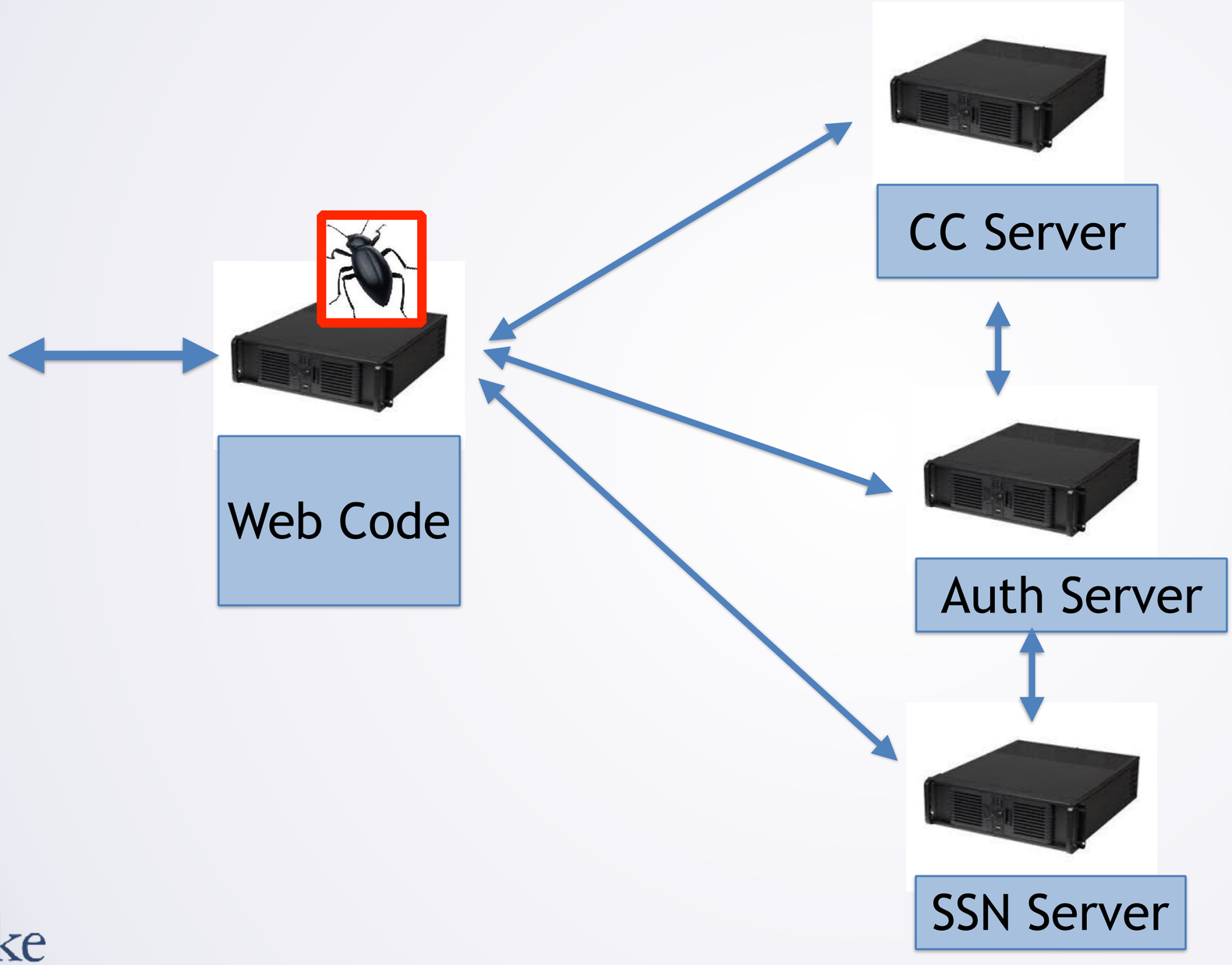
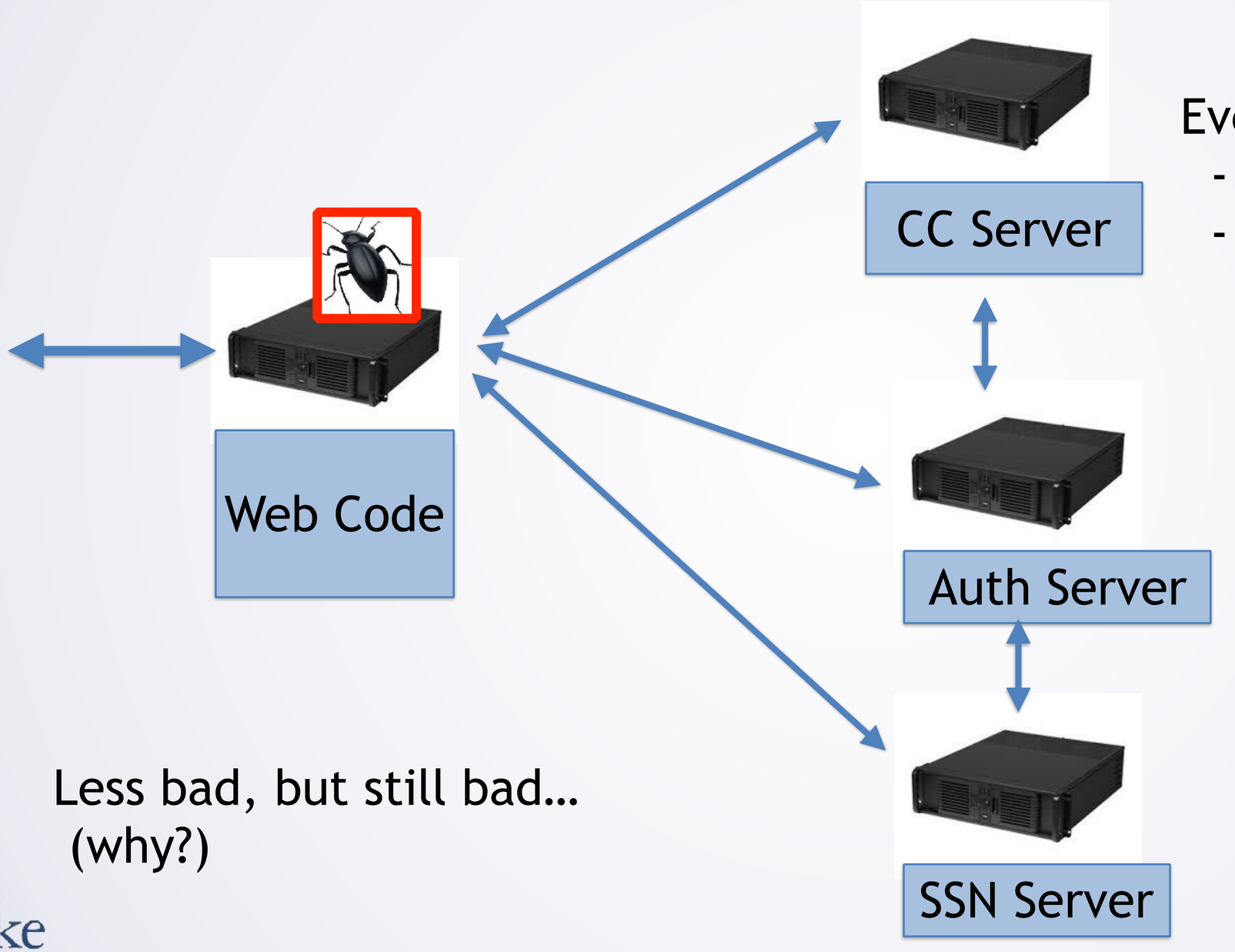


I'm going to play a longer game…

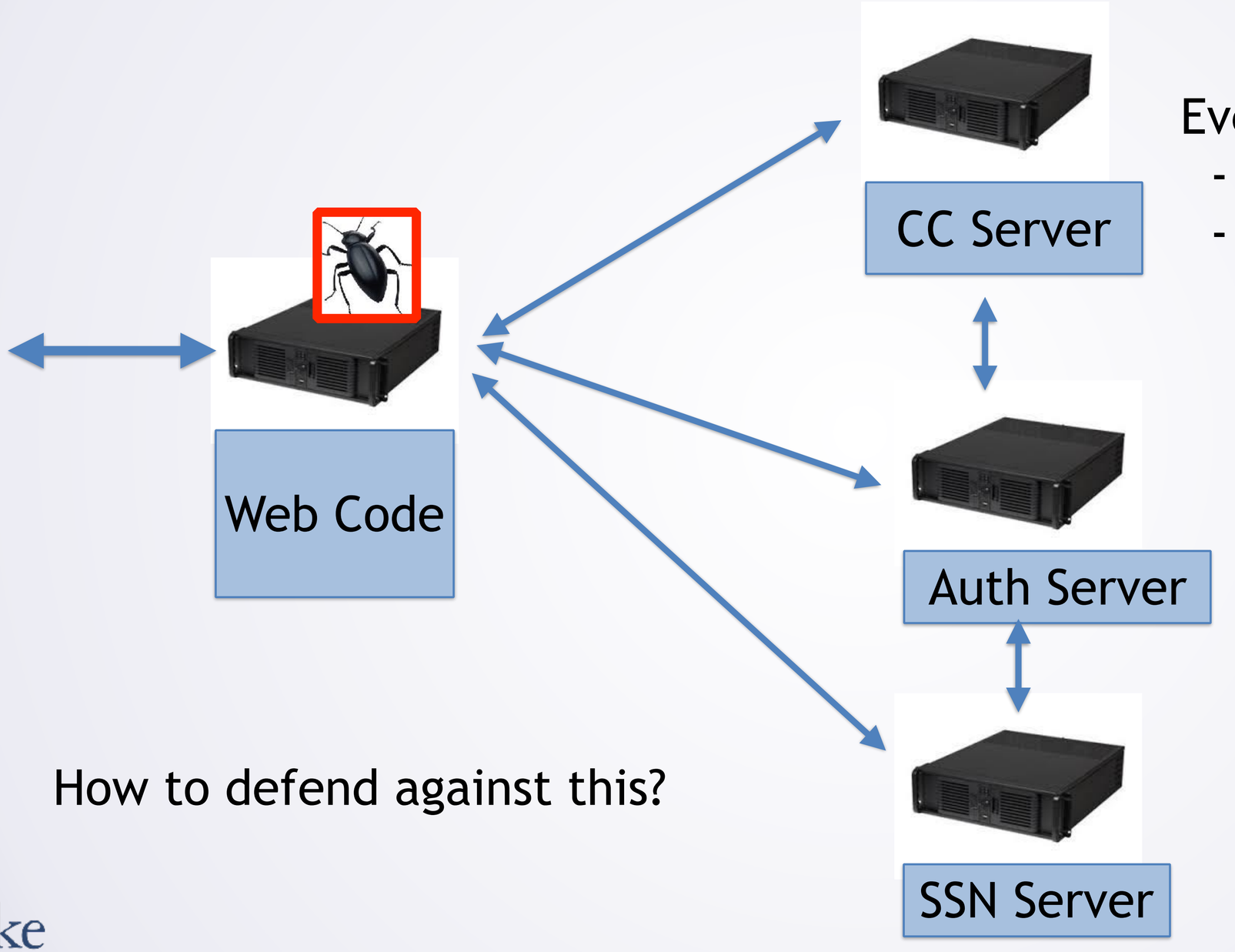
Let Us Revisit This



Every time someone logs in
- Get their auth info
- Send request to CC server
  Purchase something
  with their card

Less bad, but still bad…
(why?)

Let Us Revisit This



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- Get their auth info
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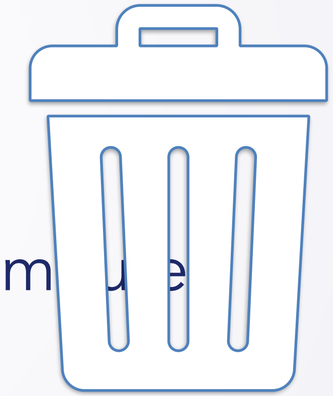
How to defend against this?

Remember this "plan"?

$$$$



- Most secure:
  - ~~Run program~~ Handle web request on a com u e
  - Throw away computer
  - Buy new computer
  - ~~Run next program~~ Handle next web request on it

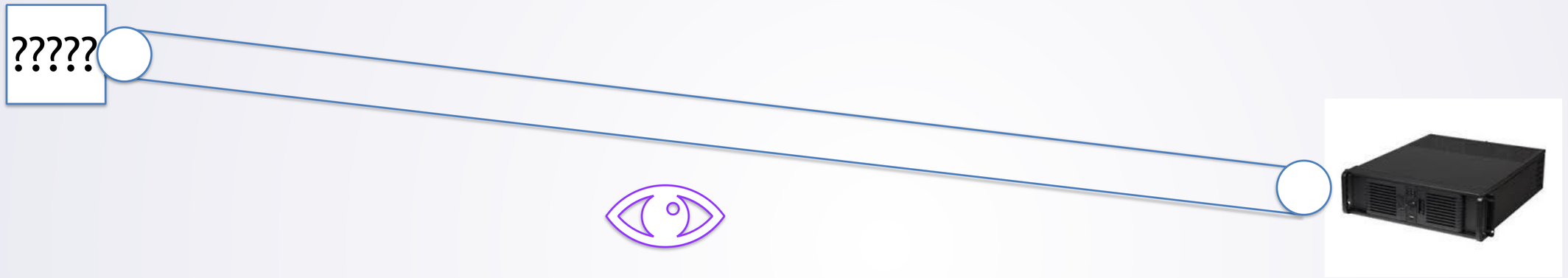
Ok that plan was bad… but

- That plan was bad, but what did we decide we could do instead?

Prevention + Detection + Response

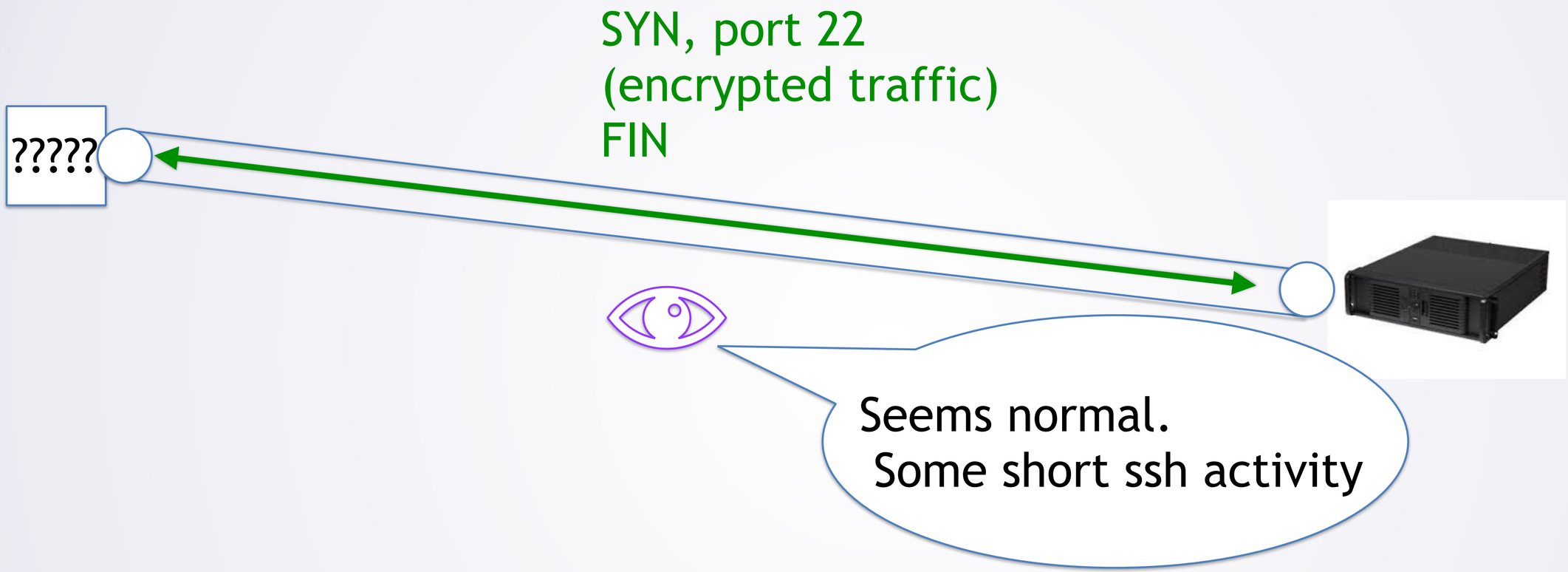
- So far have talked about **prevention**
  - Keep bad things from happening
  - Reduce badness if they do happen
- Also want **detection**
  - Know when a bad thing has happened / is happening
- …and to be able to **respond** to the attack
  - Nice if we can do something about it…

Intrusion Detection



- Monitor system for suspicious activity

Intrusion Detection



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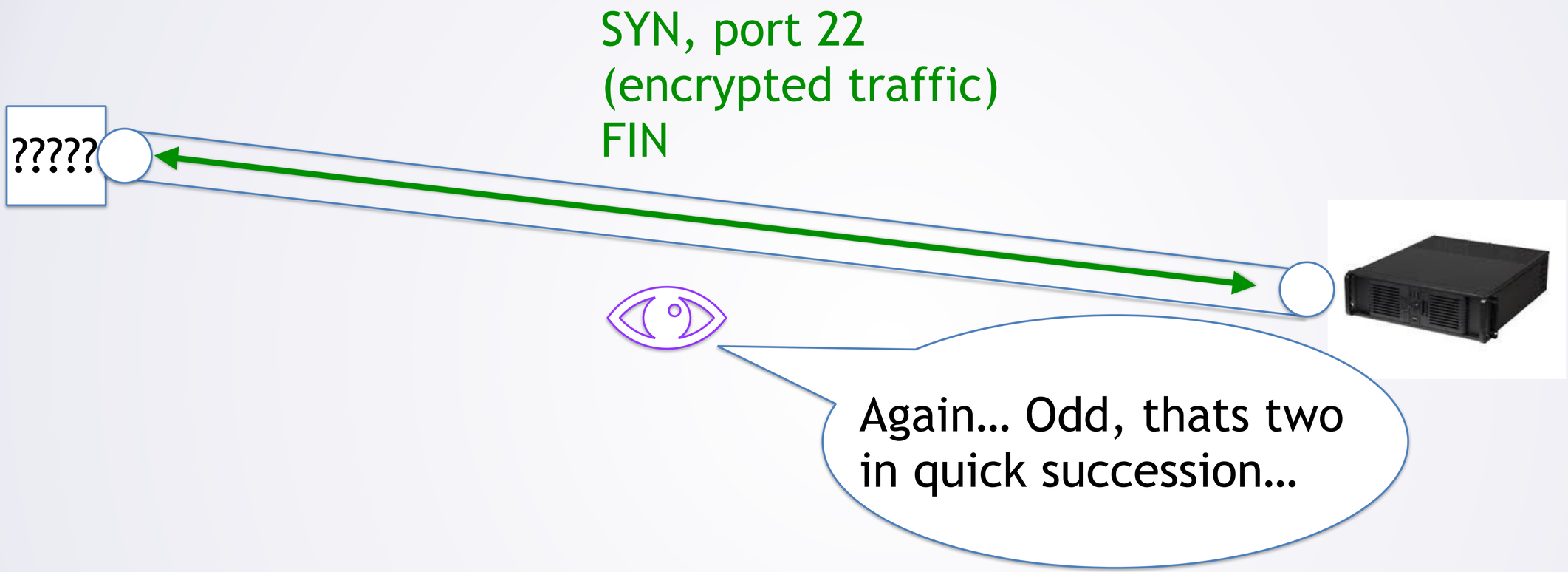

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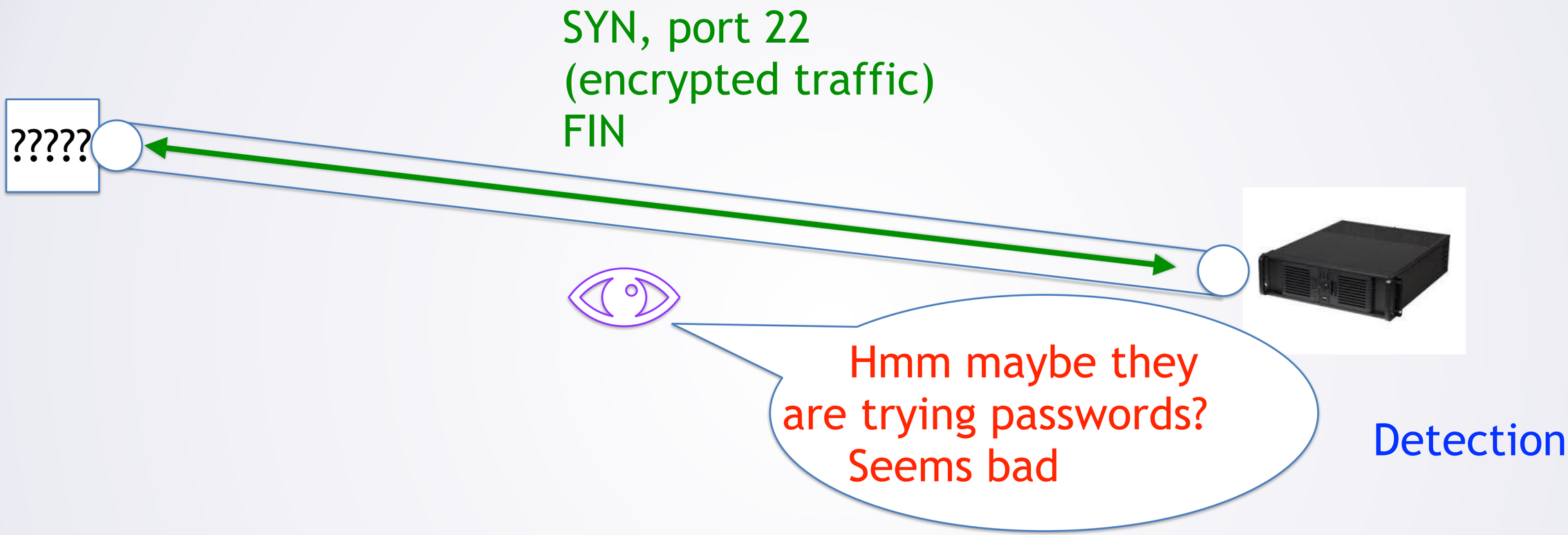

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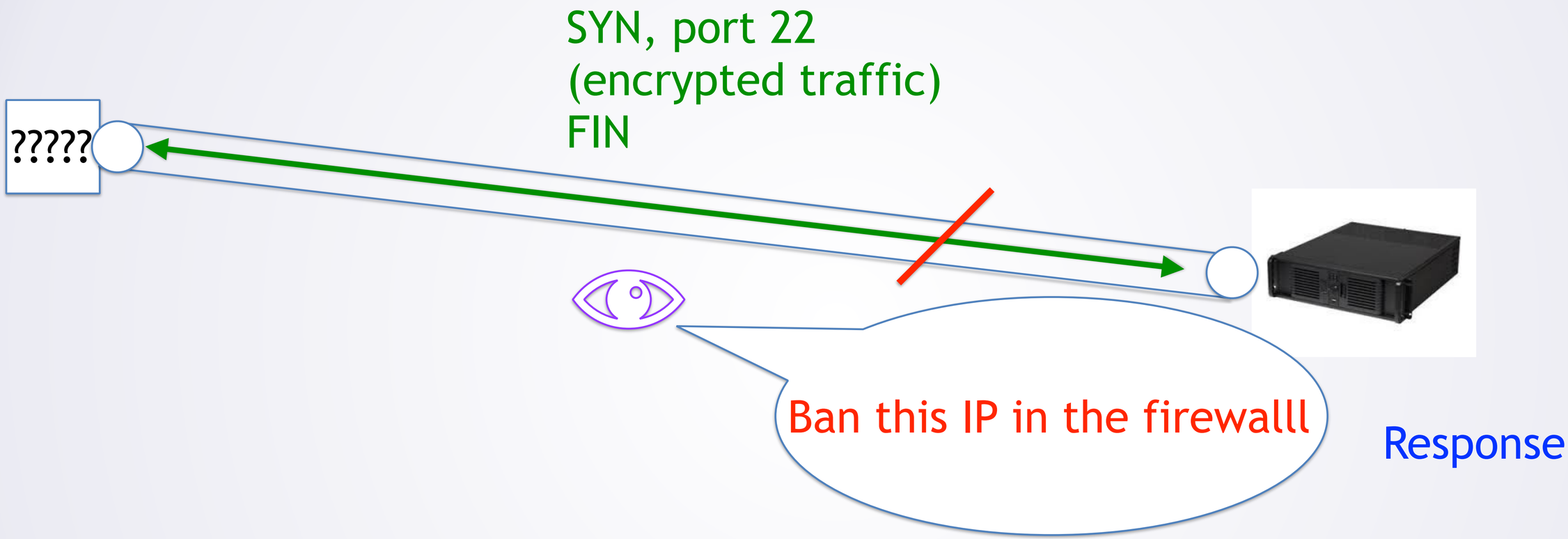

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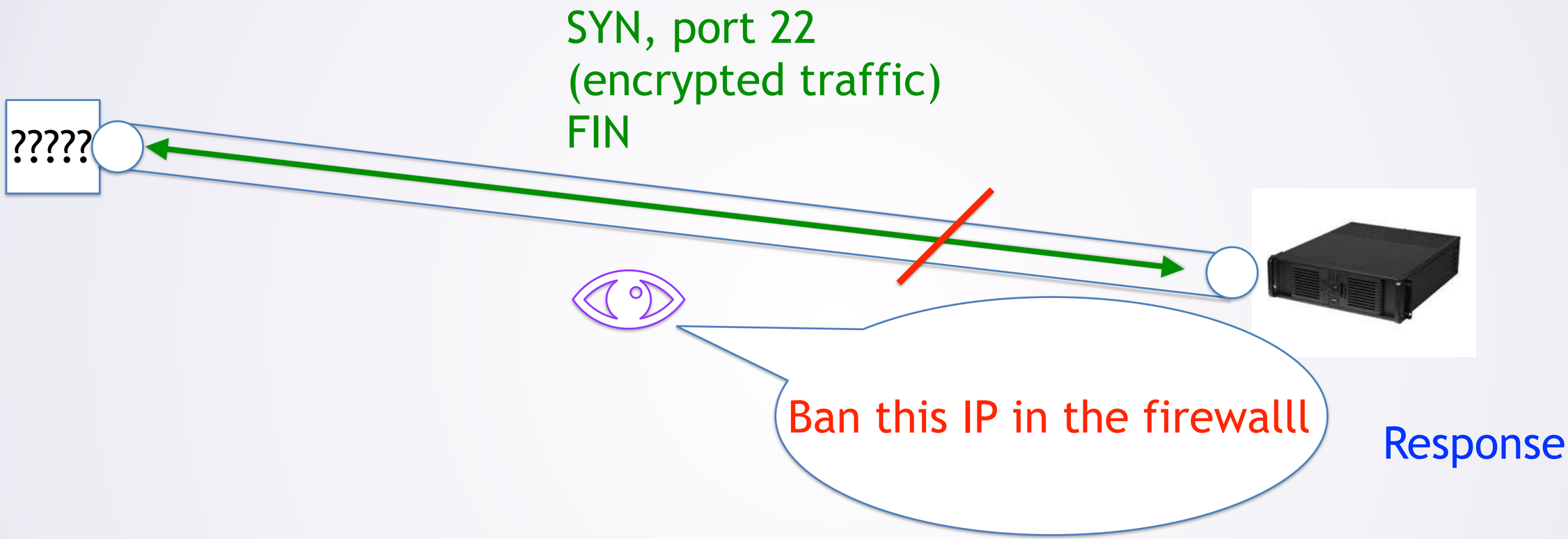


- Monitor system for suspicious activity

Was this response good?

- Detected something suspicious
- Responded strongly:
  - Blocked traffic from originating site
- Good or bad?

Was this response good?

- Detected something suspicious
- Responded strongly:
  - Blocked traffic from originating site
- Good or bad?
  - **It depends!**

Intrusion Detection

I was trying common passwords…

port 22

ncrypted traffic)

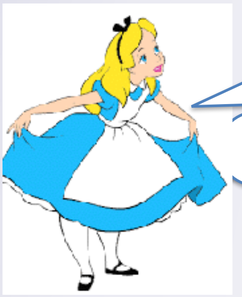
FIN

Ban this IP in the firewalll

Response

- If true positive, outcome was good

Intrusion Detection



I was just trying to scp
several small files one at a time…

traffic)

FIN

I once accidentally got CC's
IP banned by Duke's firewall
this way… Oops.

Ban this IP in the firewalll

- If **false** positive, then it was bad
  - Abnormal is not always bad

Detection

- **Automated**: Algorithmic analysis + detection
  - Signature based: look for patterns
    - This seems to be trying many passwords
    - This seems to be port scanning
  - Anomaly detection:
    - Develop ML model of normal behavior
    - Find things that deviate
- **Human**:
  - Look at logs, system behavior etc

Detection

- Not limited to network activity
  - These aren't queries that we ever run…
  - This return address has been overwritten
  - This pattern of system calls is unusual
  - There have been 4 failed login attempts for user "drew"
  - …
- Similar ideas in non-computer security
  - Bank watches credit card purchases for suspicious activity
  - Unattended bags at airport
  - …

Think Pair Share

- What could our **responses** be?
- What factors should we consider in determining an appropriate response?

Responses

- Notify administrators
  - **Send email**: Hey something is strange… Here is what is up!
  - Pros and cons?

Responses

- Notify administrators
  - Send email, text, etc: Hey something is strange… Here is what is up!
  - Pros and cons?
- Block suspicious behavior
  - Lock account, firewall traffic, ….
  - Pros and cons?

Responses

- Notify administrators
  - Send email, text, etc: Hey something is strange… Here is what is up!
  - Pros and cons?
- Block suspicious behavior
  - Lock account, firewall traffic, ….
  - Pros and cons?
- Shutdown affected system
  - Power that machine off
  - Pros and cons?

Responses

- Notify administrators
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  - Pros and cons?
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  - Pros and cons?
- Shutdown affected system
  - Power that machine off
  - Pros and cons?
- Nuke and restore from backup? (or even throw away hw?)

Factors in Choosing Response

- False positive rate
  - How certain are we that suspicious = bad?
- Severity of suspected attack
  - How bad is it?
    - Someone trying to find a vulnerability vs
    - Server was rooted
- Impacts of response on "good" users/ how many affected
  - Bad impacts: services temporarily unavailable, …
  - Good impacts: prevent leakage of sensitive info,…

Wrap Up

- Assume security measures will fail!
  - Multiple levels: mitigate damage if one fails
- Detect suspicious activity
  - Don't just assume everything is good, look for bad stuff
- Respond to threats
  - What to do: it depends…