AFW: Automating host-based firewalls with Chef

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Aweber Communications
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AFW Firewalling dynamic infrastructures (the cloud) with Chef and Netfilter

Problem

Monolithic/border firewalls will either fail under load, or contain too many rules to secure anything.

Solution

Host-based firewalls
and automated rule management.

AFW Firewalling dynamic infrastructures (the cloud) with Chef and Netfilter

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- Systems & Security Engineer at AWeber COMMUNICATIONS
- I built and secure web infrastructures on Linux
- http://www.github.com/jvehent/
- http://jve.linuxwall.info

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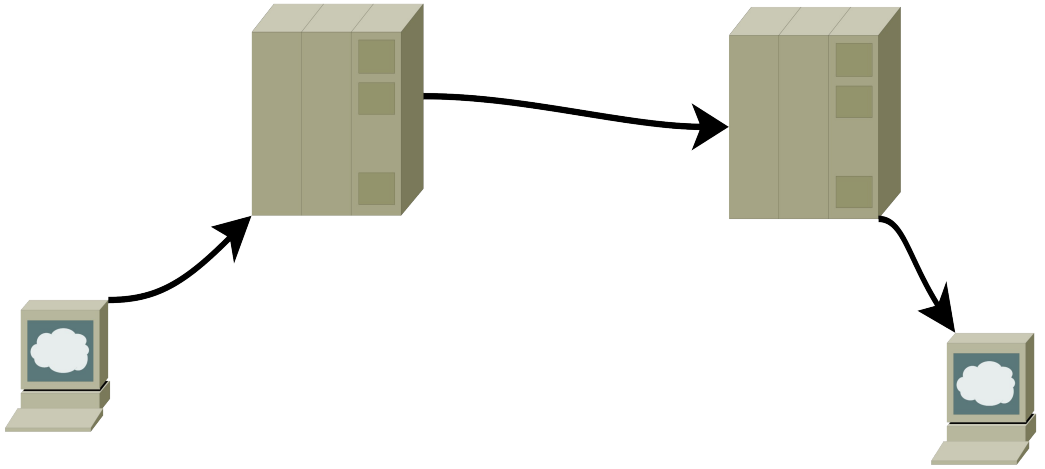
The 70's Firewall design



ping ?

WHHAAAA !!!!
I GOT A PING !!!!

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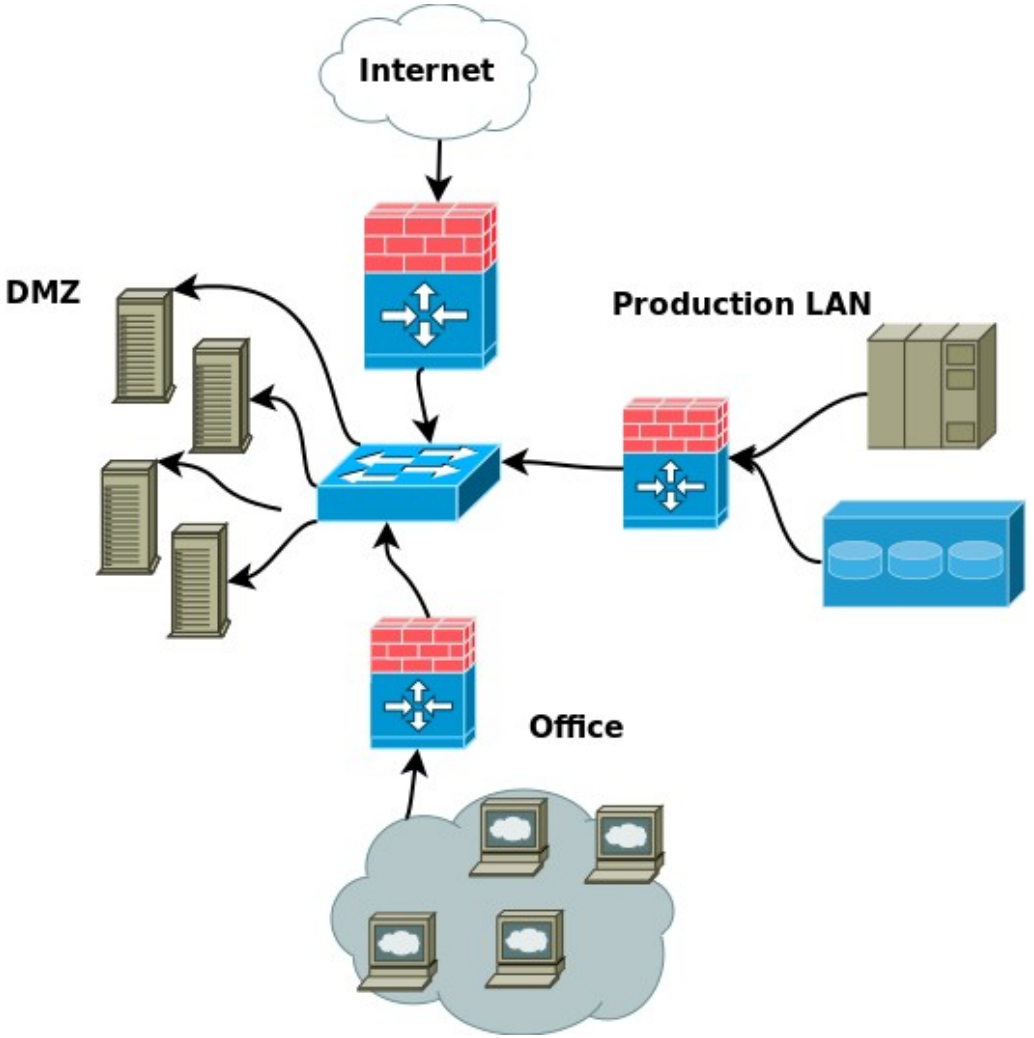
The 90's Firewall design



- Few powerful & expensive firewalls filter the entire traffic
- DMZ design: works with small DMZs
- Rules maintained manually: need a route opening/closing workflow

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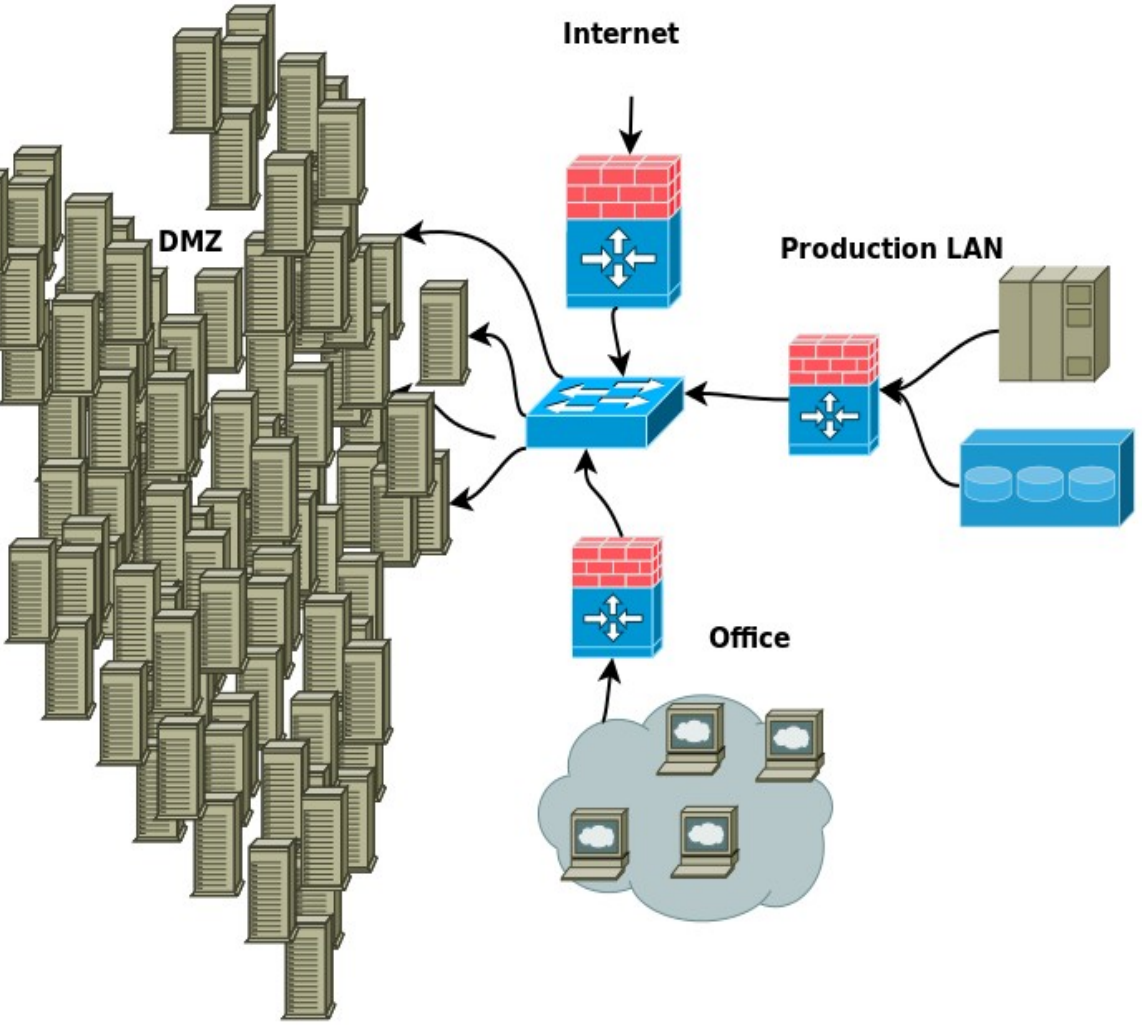
2000 Firewall ~~design~~ failure



- “Let's keep pilling stuff in the DMZ, it needs to be accessed from the Internet anyway.”
- Really complex rule opening workflow
- Rules are closed when someone happens to look at the firewall at 4am on a sunday morning.

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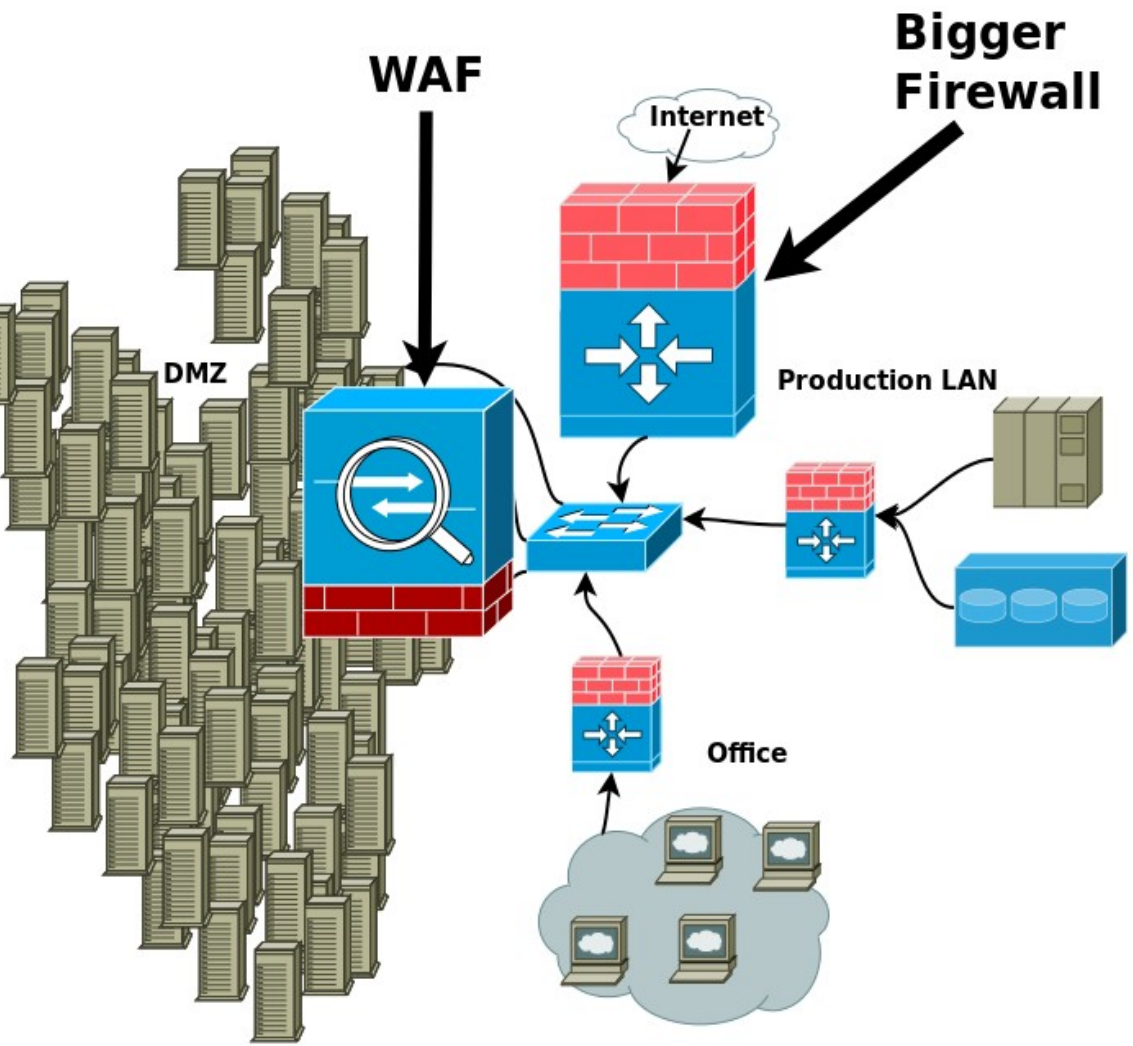
2005: We Need More !



- **Bigger** firewalls
- NIDS, NIPS, HIDS
- Web App Firewall, Database firewalls
- Logs centralizers, Logs analyzers, Logs readers
- Developers stopped trying to connect application A to server B somewhere around 2008

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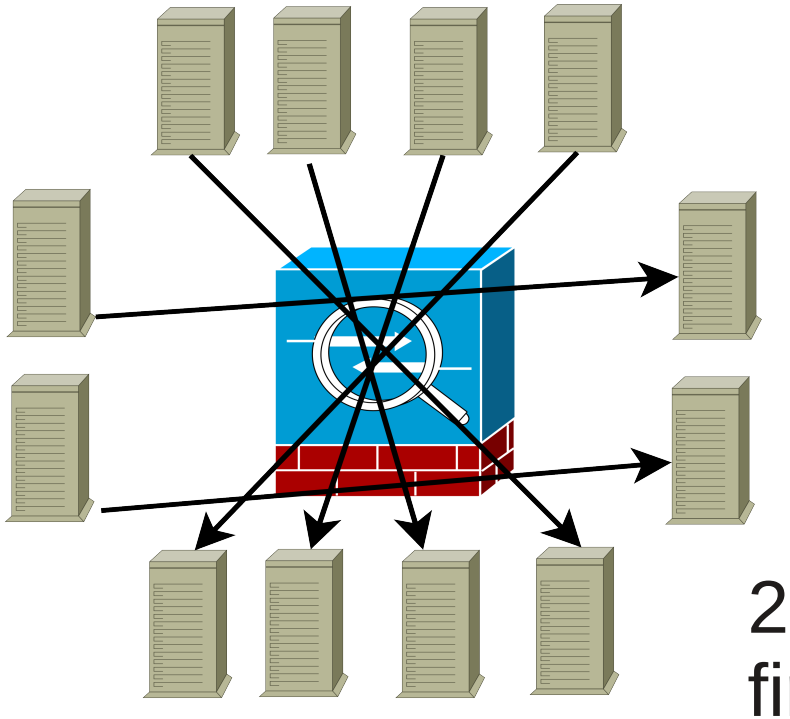
2010: Congratulations !



You are now routing your entire datacenter traffic through a handful of appliances from very happy vendors.

25,000 IDS alerts per day, 6GB of firewall logs, added 300ms of latency everywhere... sounds familiar ?

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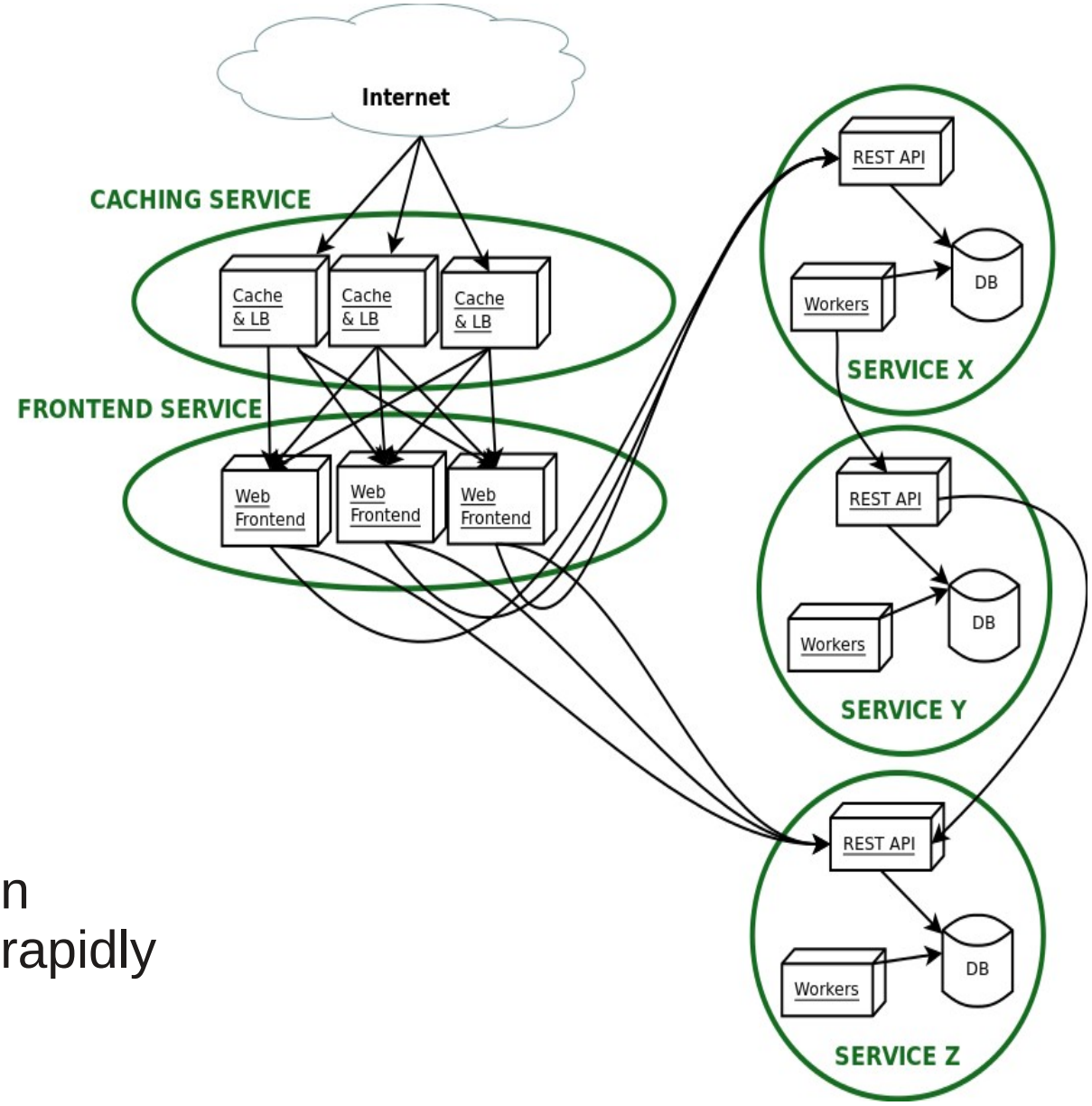
Service Oriented Architecture

- Services are autonomous
- Services call each other using a standard protocol (REST: JSON over HTTP)
- The architecture is described by a list of dependencies between services



"Cloud" type requirements:

- No single point of failure
- Optimize resources utilization
- Augment & reduce capacity rapidly

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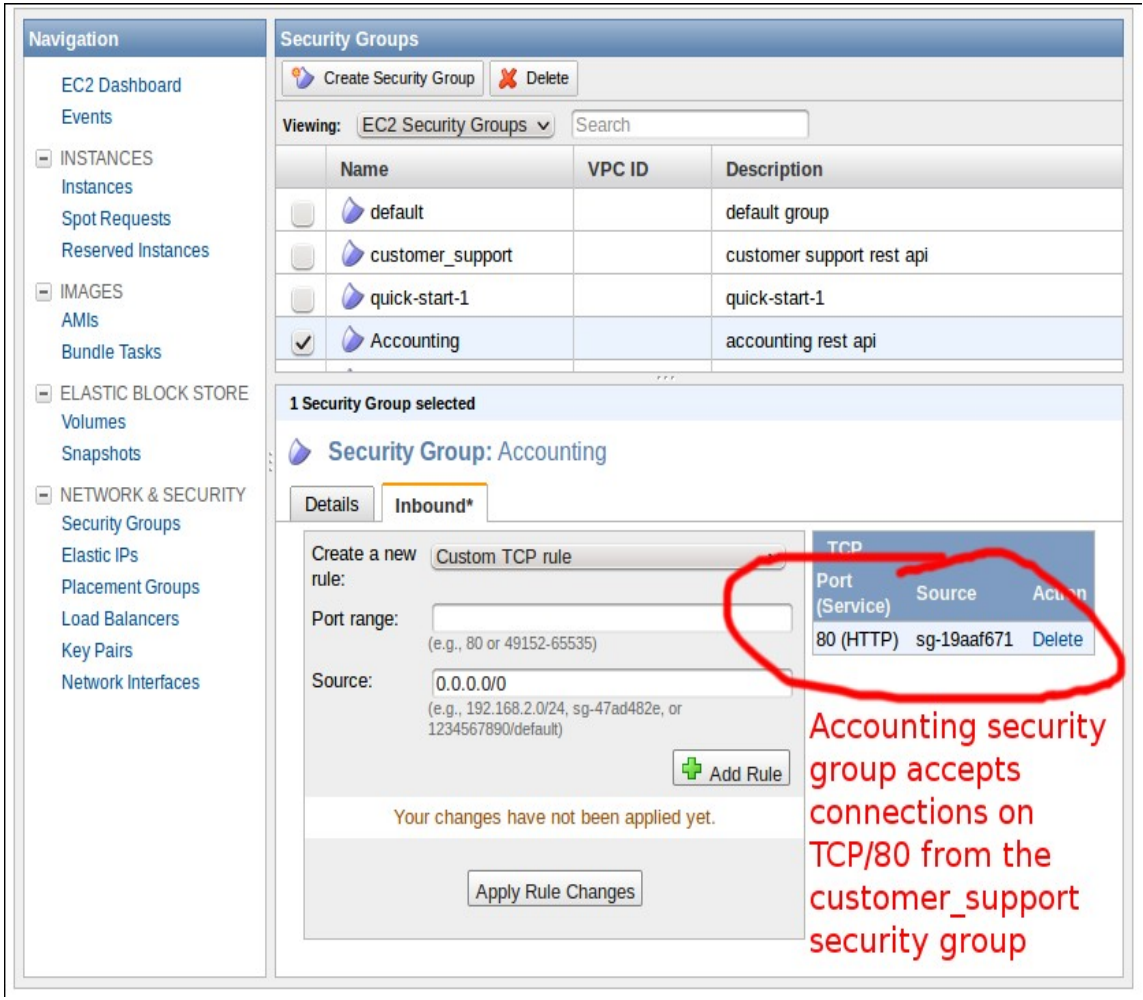
Service Oriented Security

AWS security groups (SG)

- Create SG-X for service X
- Create SG-Y for service Y
- Allow SG-X to connect to SG-Y
- All instances (servers) in SG-X will be allowed to connect to SG-Y

=> Dynamic security: No need to update the firewall for each new server



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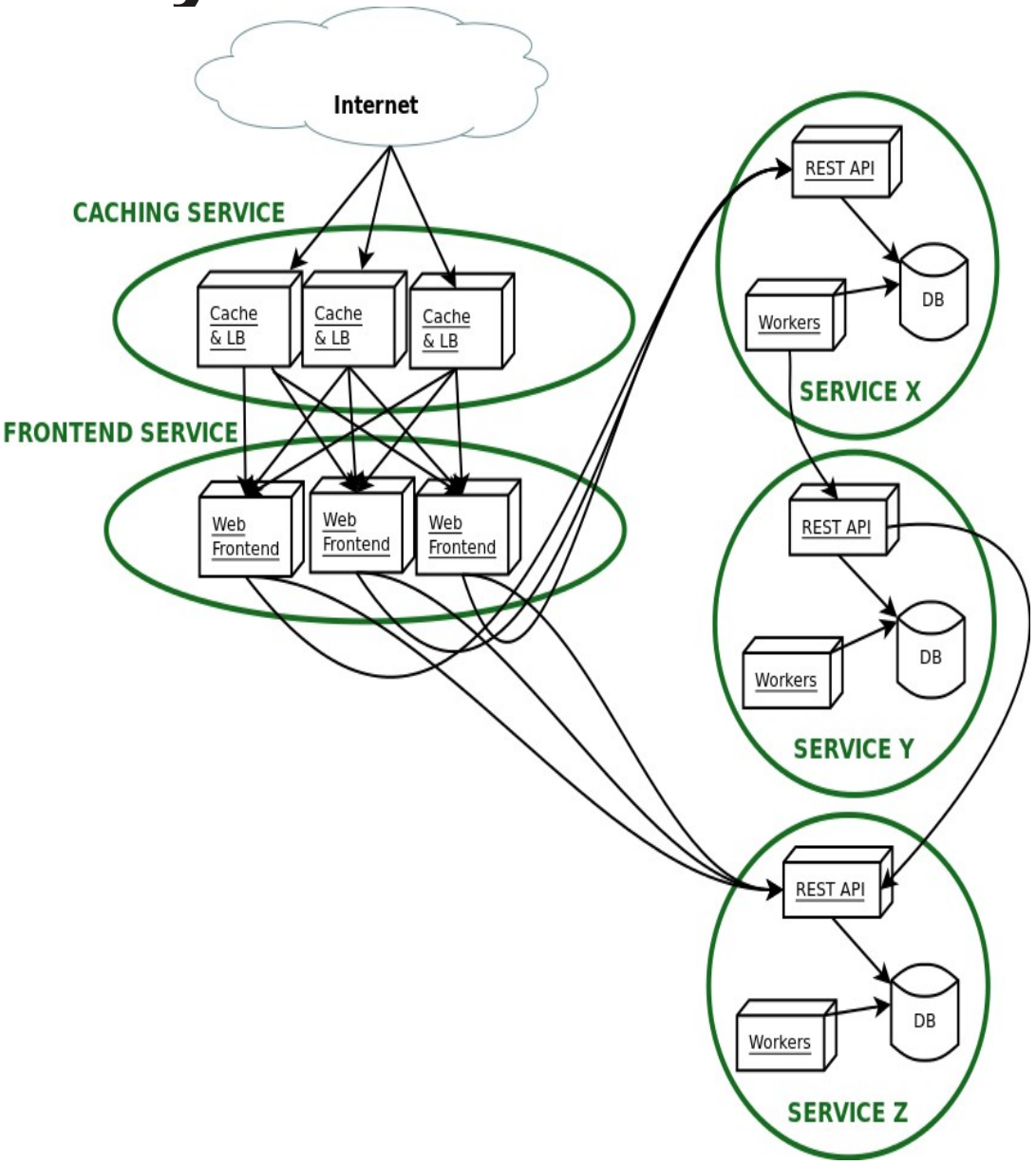
Service Oriented Security

Inter-services policy

```
ACCEPT 0.0.0.0/0 to CACHING on TCP/80

ACCEPT CACHING to FRONTEND on TCP/80

ACCEPT FRONTEND to ServiceX on TCP/80

ACCEPT FRONTEND to ServiceZ on TCP/80

ACCEPT ServiceX to ServiceY on TCP/80
```

Intra-service policy

```
ACCEPT API to DB on TCP/5432

ACCEPT Workers to DB on TCP/5432
```



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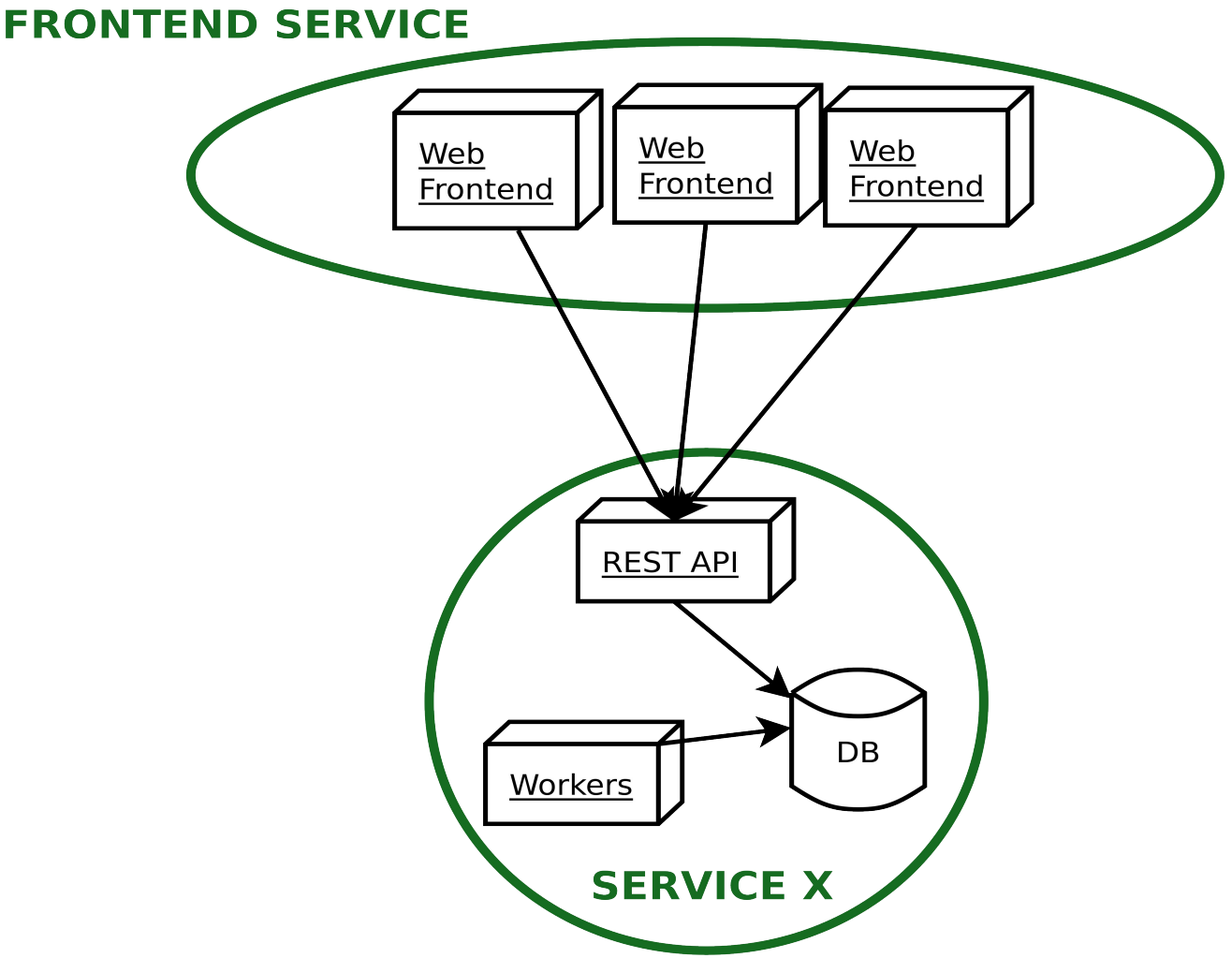
Scalability (you know, the cloud)



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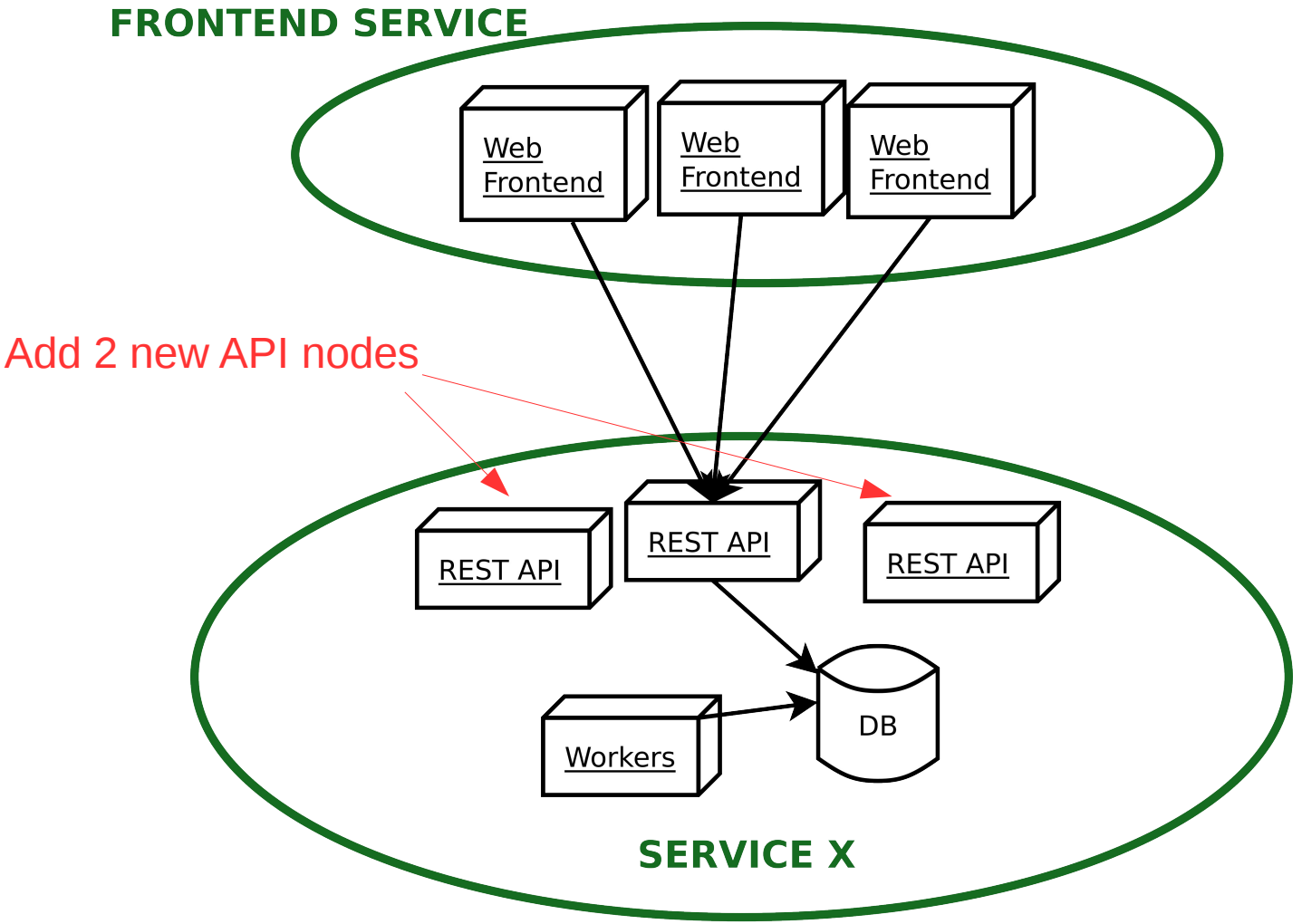

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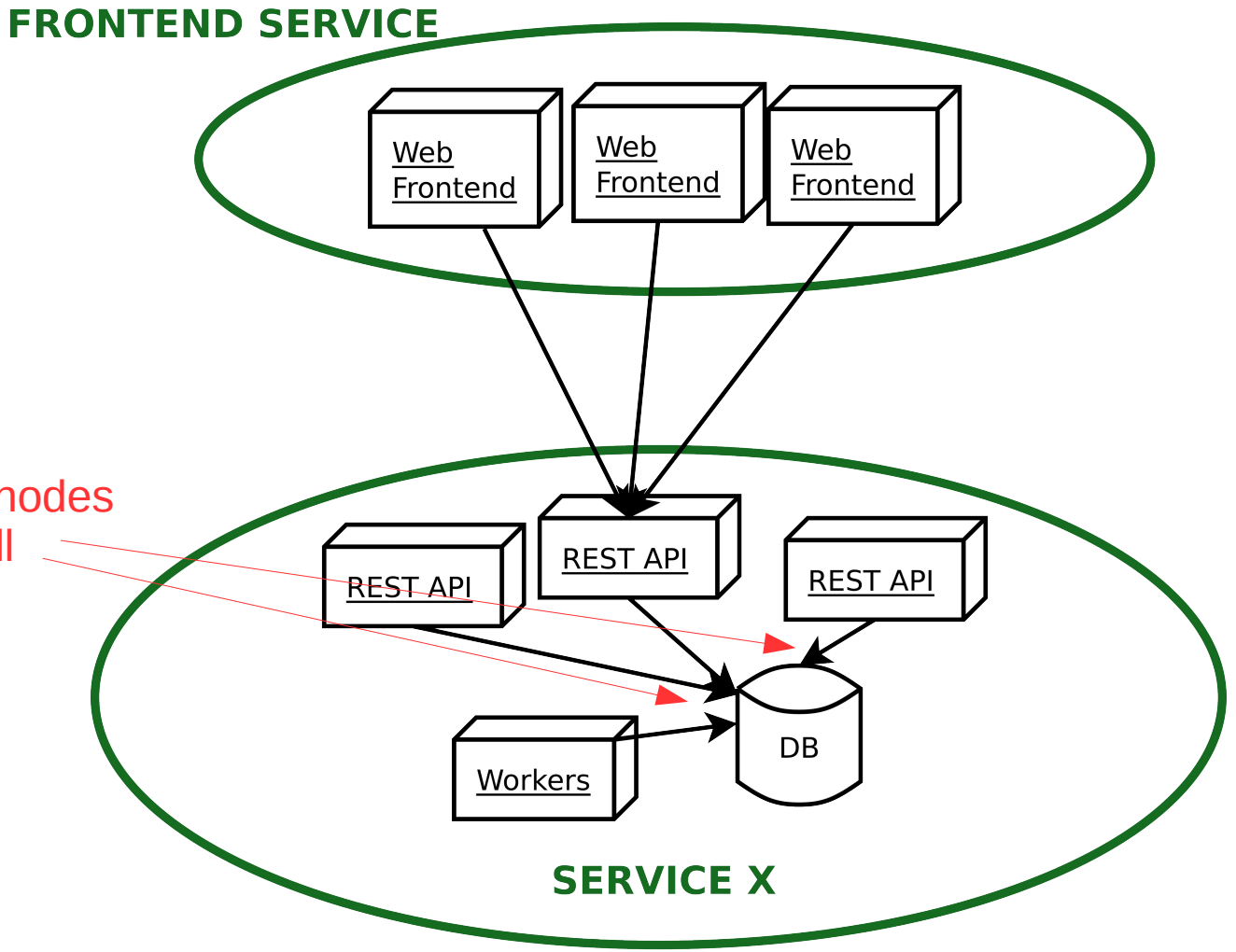

Allow the 2 API nodes in the DB firewall

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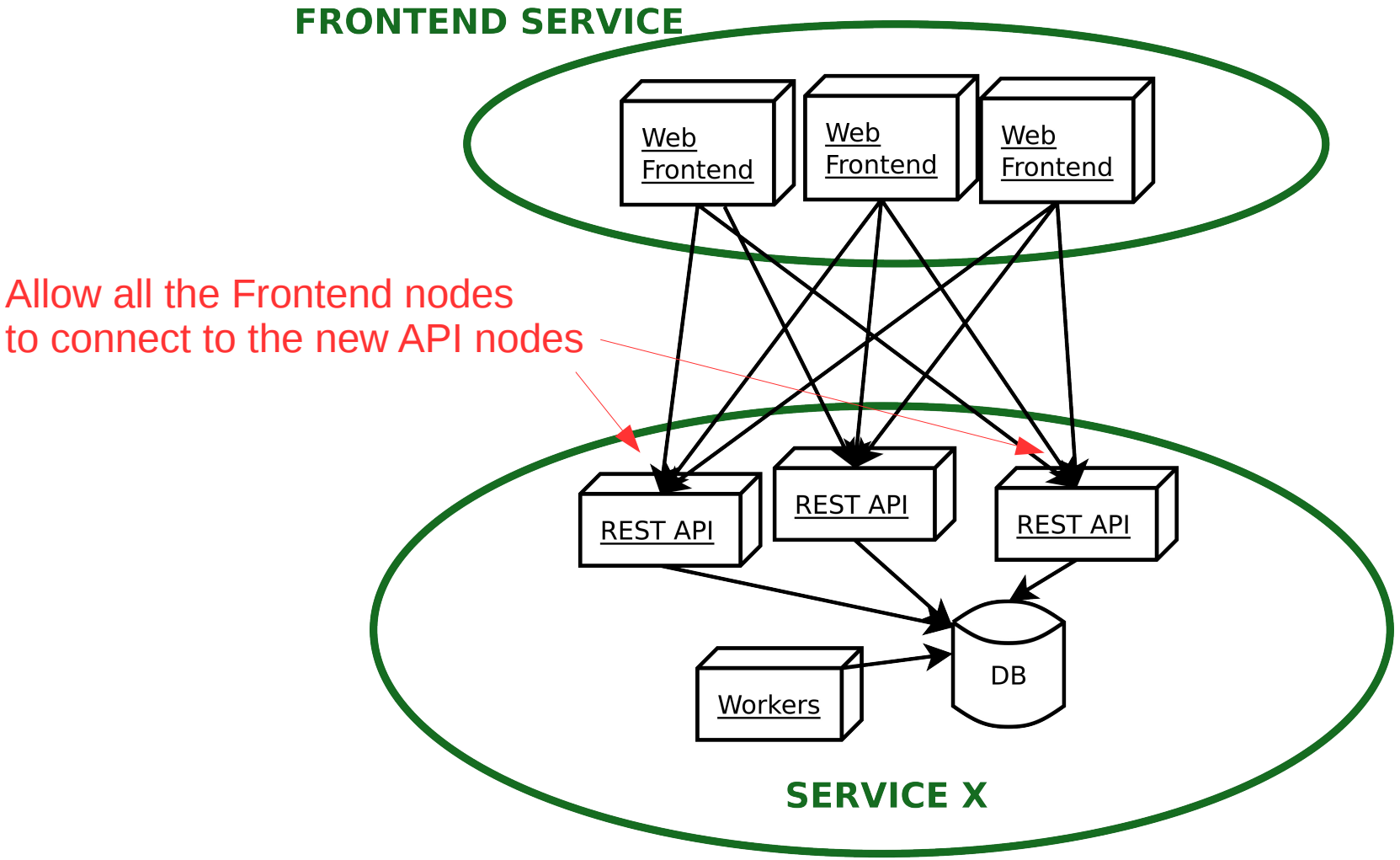
Scalability (you know, the cloud)



The Tool: Chef

- Chef is a **provisioning** tool (puppet, cfengine, ol'-school-bash-script)
- **Cookbook**: ruby/chef scripts that installs and configure something.
- **Role**: a set of configuration value and a list of cookbooks to run.
- Administrator assigns a role to a **node** (server). Chef will run on the node, pull the list of cookbook and configuration variables, and install stuff on the node... and repeat again every X minutes.
- Files managed by Chef can't be edited manually.
- Each node indexes tons of metrics from running systems and store them in a central database (couchdb in Chef10, postgres in Chef11). It contains everything that you've ever dreamed of, and more !

Chef Searches


```
$ knife search node "roles:web-frontend AND chef_environment:staging"

3 items found
  Node Name:   frontend1.staging.domain
  Environment: staging
  FQDN:        frontend1.staging.domain
  IP:          172.21.1.2
  Run List:    role[base], role[web-frontend]
  Roles:       rsyslog-client, snmp-base, nagios-client, ntp-client,
  chef-client, ossec-agent, openldap-client,   web-frontend
  Recipes:     ohai, timezone, ntp, afw, apt,  system-tools, sysctl,
  nagios::client, snmp, diamond,   openldap::client, sudo, rsyslog,
  ossec::agent, nginx, varnish
  Platform:    centos 6

  Node Name:   frontend2.staging.domain
  Environment: staging
  FQDN:        frontend1.staging.domain
  IP:          172.21.1.3
  Run List:    role[base], role[web-frontend]
...
```

Chef Searches

```
# Get all the agents at once, more efficient
ossec_agents = search(:node,
                      "roles:ossec-agent AND chef_environment:prod")

ossec_agents.each do |agent|
  # this agent is running fine, go to the next one
  if ossec_agent_is_active?(agent_hash[:id])
    node.set[:ossec][:agents][agent_hash[:id]][:status] = "active"
    next
  else
    create_ossec_agent(agent_hash[:id])
    # Etc...
  end
end
```

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Because Chef can search the entire infrastructure, it can be used to generate a firewall policy dynamically.

All we need is a syntax to declare the policy, and a cookbook to apply it.

Meet **AFW**

AFW Firewalling dynamic infrastructures (the cloud) with Chef and Netfilter

A{daptative,utomated,Weber,...} FireWall

- **Concepts**
  - Automated ruleset generation
  - 1 to 1 rules only: connection from one node to another is represented by one rule (no range opening)
  - User-specific outbound firewall: one user, identified by **UID**, can connect to one ip:port destination
  - Generic rules: avoid writing custom rules for each node, write rules for type of service instead
- **Technology**
  - Stock iptables-save format
  - Reload the ruleset every time chef runs, flushes unwanted rules
  - Netfilter features:
    - Fast reload: iptables-restore
    - Owner match (xt_owner)
    - Conntrack (xt_conntrack)

AFW: the syntax

- Rules are ***attributes*** of the AFW cookbook, and can be defined in roles, or other cookbooks

- Open INPUT access to rabbitmq

  port to a small list of servers

```
'RabbitMQ AMQP Producers' => {
  :direction => 'in',
  :user => 'rabbitmq',
  :protocol => 'tcp',
  :interface => 'default',
  :source => ['producer1.production.domain',
              'producer2.production.domain',
              'producer1.staging.domain'],
  :dport => '5672'
},
```

- Same, but in the staging

  environment only

```
'MongoDB Staging access from Jenkins' => {
  :direction => 'in',
  :protocol => 'tcp',
  :user => 'mongodb',
  :dport => '27017',
  :source => ['jenkins1.production.domain',
              'jenkins2.production.domain'],
  :interface => 'all',
  :env => 'staging'
}
```

AFW: Searches

- Uses Chef's search capabilities to list the nodes allowed to connect.
- Open the firewall between a server and its clients. On the right, for Ossec.
- Open a backend database to application servers, below for mongodb.

```
'MongoDB App Entry Point' => {
  :protocol => 'tcp',
  :direction => 'in',
  :user => 'mongodb',
  :source => '(roles:nodejs
              OR roles:python-worker
              OR roles:api-server)'
  :dport => '27017'
},
```

```
default_attributes(
  :afw => {
    :rules => {
      'ossec_agent_to_server' => {
        :direction => 'in',
        :protocol => 'udp',
        :user => 'ossec',
        :dport => '1514',
        :source => 'roles:ossec-agent'
      },
      'ossec_server_to_agent' => {
        :direction => 'out',
        :protocol => 'udp',
        :user => 'ossec',
        :dport => '1514',
        :destination => 'roles:ossec-agent'
      }
    }
  },
```

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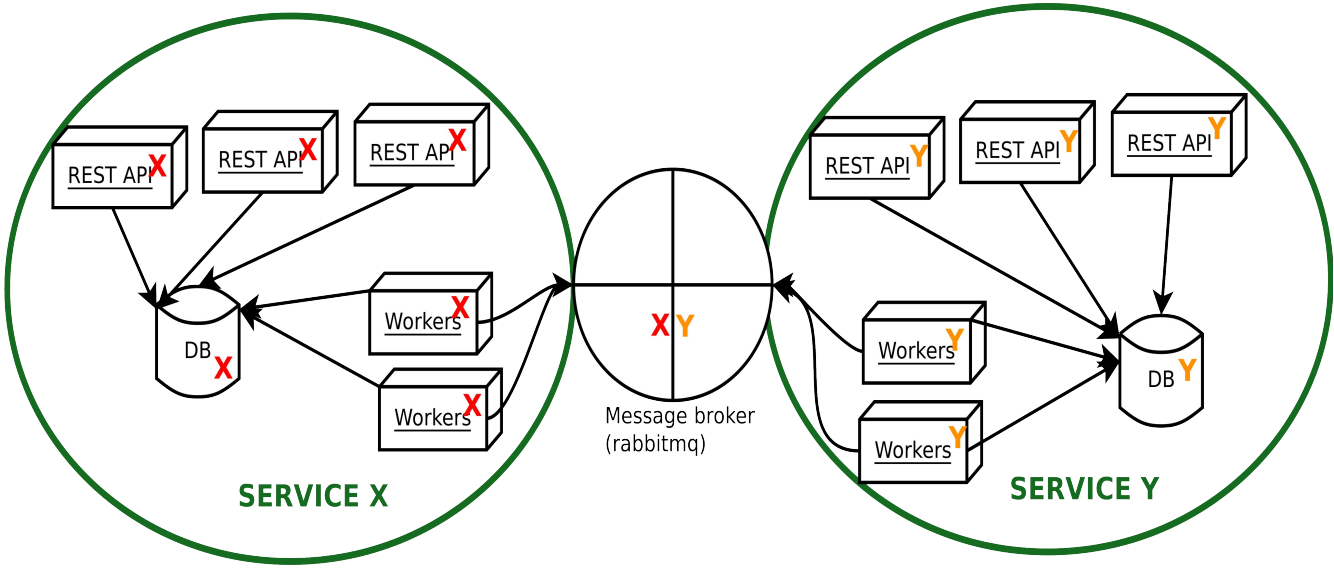
AFW: The notion of service

- AFW rules are generic across all services
- **tag** identifies the members of a service
- Ex: database accepts connections from the app servers in its service



All nodes in Service X are tagged `X`.
All nodes in Service Y are tagged `Y`.
The message broker has both `X` and `Y` tags

```
'Accept connections from app servers' => {
  :protocol => 'tcp',
  :direction => 'in',
  :user => 'postgres',
  :destination => 'roles:app-server AND SAMETAG',
  :dport => '5432'
},
```

```
roles:mongodb AND tags:X AND chef_environment:#{node.chef_environment}
```

```
→ returns: ['REST-API-X1','REST-API-X2','REST-API-X3',
            'Worker-X1', 'Worker-X2']
```

AFW: firewall a mongodb cluster

- When building a MongoDB cluster, all members share the same “shard”.
- Chef knows the name of the shard, in the **shard_name** attribute.
- **shard_name** is used in a source/destination search to find the members of a cluster, and open the firewall to them

```
'MongoDB Cluster Inbound Replication' => {
  :protocol => 'tcp',
  :direction => 'in',
  :user => 'mongodb',
  :source => 'shard_name:#{node[:mongodb][:shard_name]}',
  :dport => '27017'
},
'MongoDB Cluster Outbound Replication' => {
  :protocol => 'tcp',
  :direction => 'out',
  :user => 'mongodb',
  :destination => 'shard_name:#{node[:mongodb][:shard_name]}',
  :dport => '27017'
},
```

AFW: Unusual rules ? Predefine them.

- Predefined rules are copied verbatim into the iptables ruleset. No interpretation.

```
:afw => {
  :rules => {
    'Accept all packets router through the bridge' => {
      :table => 'filter',
      :rule => '-I FORWARD -o br0 -m physdev --physdev-is-bridged -j ACCEPT'
    },
    'Drop connection to the admin panel on the eth0 interface' => {
      :table => 'mangle',
      :rule => '-A INPUT -i eth0 -p tcp --dport 80 -m string --string "get /admin
http/1.1" --icase --algo bm -m conntrack --ctstate ESTABLISHED -j DROP
    },
    'DNAT a source IP to change the destination port' => {
      :table => 'nat',
      :rule => '-A PREROUTING -i eth3 -s 201.23.72.3 -p tcp --dport 8008 -j DNAT
--to-destination 127.0.0.1:1234'
    },
    'Dont do conntrack on this specific user's UDP packets' => {
      :table => 'raw',
      :rule => '-A OUTPUT -o eth0 -p udp -m owner --uid-owner 105 -j NOTRACK'
    }
  }
}
```

AFW: Limitations

- The entire security relies on the security of the Chef server (true for all provisioning systems)

- Nodes can modify their own Chef attributes. If **one node gets hacked**, it can modify its run_list, environment and tags to impersonate another node !

```
root@hackedserver# shef -z
  chef > node.tags
   => ["foo"]
  chef > node.tags.push("bar")
   => ["foo", "bar"]
  chef > node.save
   => <Chef::Node:0x3fc6a2c3b830 @name="hackedserver.domain.net">
  chef > node.tags
   => ["foo", “bar”]
```

Future Work

- Ipset
  - If a search returns more than {10? 20 ? 100?} IPs, automatically create an Ipset.
- Forward rules
  - Use AFW to manage the FORWARD rules of a border firewall
- IPv6
- Ebtables
- Support for more modules (time, string, …)

Future Work: Service Oriented Security

- Instead of managing the firewall as a network policy, manage it as an Access Control List

```
"application": {
  "accounting": {
    "dependencies": {
      "applications": [ "printing", "human-ressources" ],
      "infrastructure": [ "graphite", "internal-smtp" ]
      "external": [ "https://api.salesforce.com",
                    "https://api.paypal.com" ]
    }
  },
  "human-ressources": {
    "dependencies": {
      …
    }
```

Questions ?

- **https://github.com/jvehent/AFW/**
- **http://community.opscode.com/cookbooks/afw**

AFW: Open rules “on-the-fly”

- When we can't create generic rules ahead of time, we can let a cookbook create its own rules.
- AFW's core functions can be called from another cookbook. It's all Ruby.

```
# Call the AFW module to create the rule
AFW.create_rule(node,
                "Haproxy local LB to #{server['hostname']}:#{port}",
                {'protocol' => 'tcp',
                 'direction' => 'out',
                 'user' => 'haproxy',
                 'destination' => "#{server['ipaddress']}",
                 'dport' => "#{port}"
                })
```

- Useful, but harder to diagnose. Use with caution.

AFW: User specific Outbound rules

- Netfilter's INPUT chain cannot check the owner of the socket
- But the OUTPUT chain can:
  - Example with the `root` user

```
-A OUTPUT -m owner --uid-owner 0 -m state --state NEW -j root
:root – [0:0]
# Root user is allowed to connect to the RSYSLOG server
-A root -o eth1 -p tcp --dport 514 -d 172.31.15.13 -m conntrack --ctstate NEW -j ACCEPT
# Root is also allowed to connect anywhere in TCP
-A root -p tcp --dport 1:65535 -d 0.0.0.0/0 -m conntrack --ctstate NEW -j ACCEPT
# Everything else is logged
-A root -j LOG --log-prefix "DROP_AFW_OUTPUT_root " --log-uid --log-tcp-sequence
```

  - The `nagios` user has much less permissions

```
-A OUTPUT -m owner --uid-owner 107 -m state --state NEW -j nagios
:nagios – [0:0]
# Nagios local user is allowed to connect to the Nagios server
-A INPUT -i eth1 -p tcp --dport 5666 -s 172.31.12.42 -m conntrack --ctstate NEW -j ACCEPT
-A nagios -j LOG --log-prefix "DROP_AFW_OUTPUT_nagios " --log-uid --log-tcp-sequence
```