Running Isolated VirtualClusters with Kata & Cluster API

Eric Ernst & Chris Hein

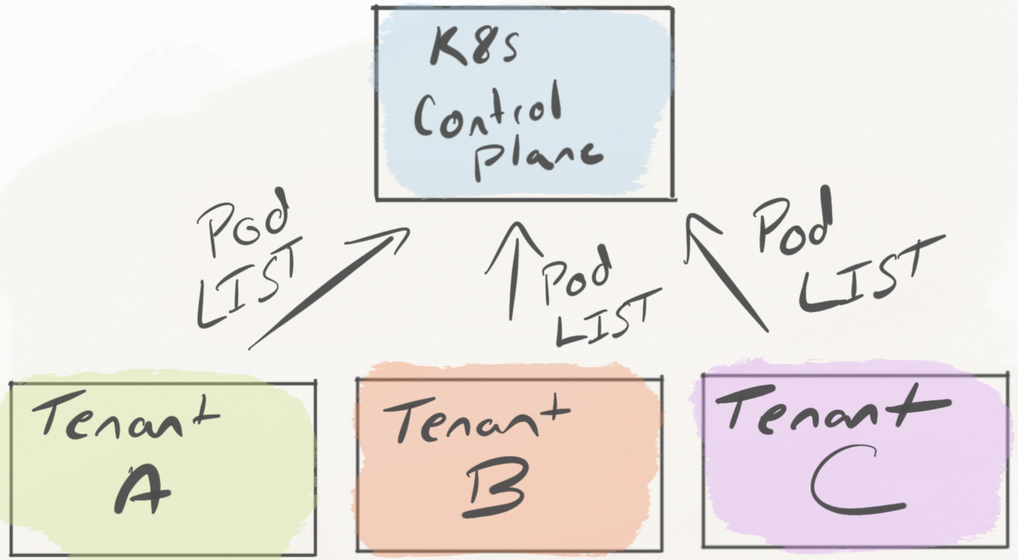
Multi-Tenancy in Kubernetes is hard.

Hard Multi-tenancy is even harder.

Multi-Tenant Control Planes

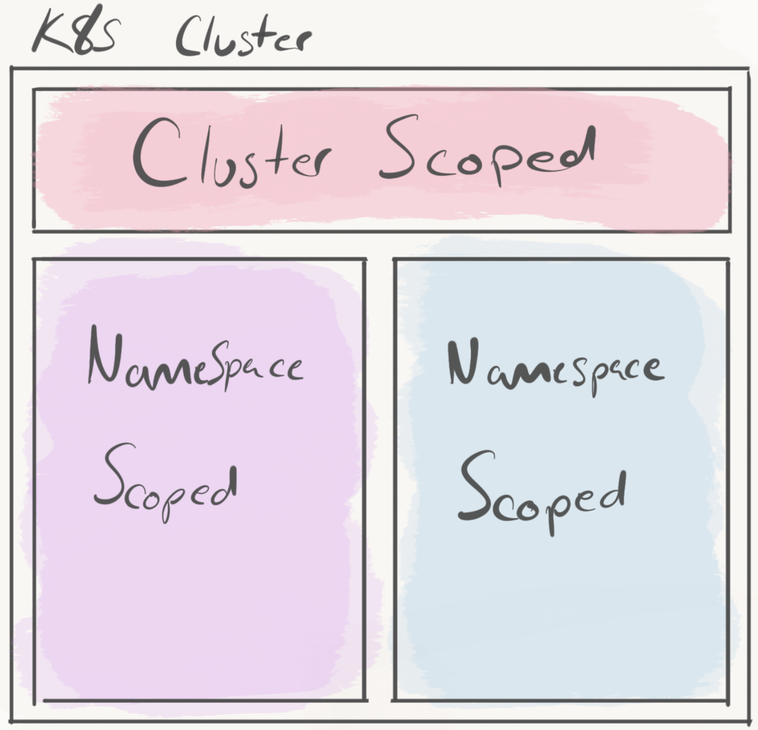
Issues with Multi-Tenant Control Planes

✗ Clumsy Clients



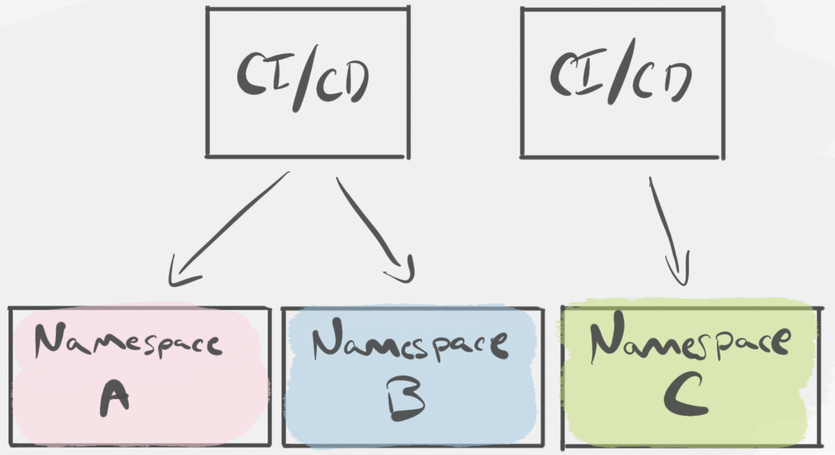
Issues with Multi-Tenant Control Planes

- ✗ Clumsy Clients
- ✗ Access to Cluster Scoped Resources

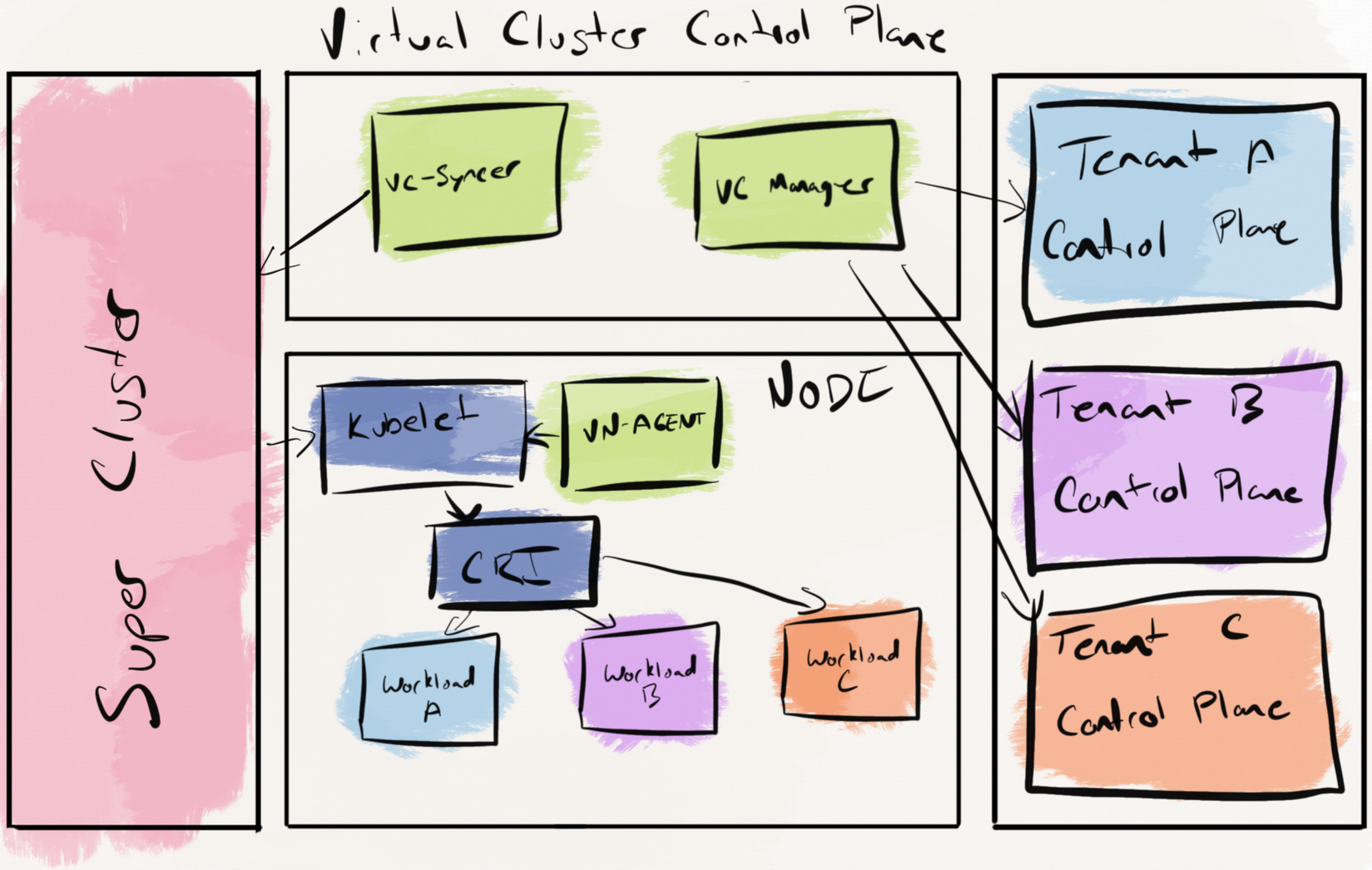


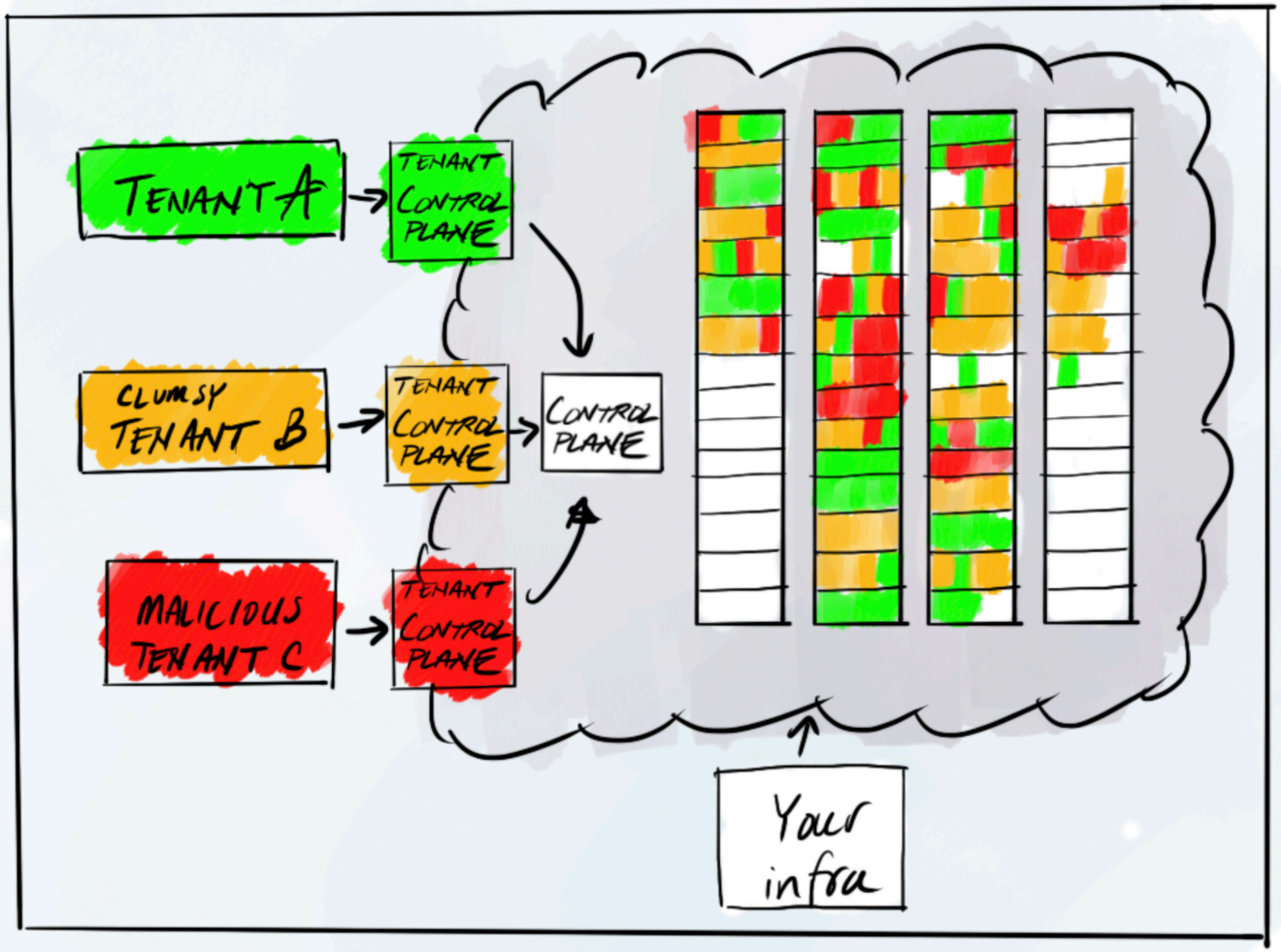
Issues with Multi-Tenant Control Planes

- ✗ Clumsy Clients
- ✗ Access to Cluster Scoped Resources
- ✗ Usage of Cloud Native Tools



Isolating Control Planes


Virtual Cluster Control Plane
Super Cluster
vc-syncer
VC Manager
Tenant A Control Plane
Tenant B Control Plane
Tenant C Control Plane
NODE
Kubelet
VN-AGENT
CRI
Workload A
Workload B
Workload C


TENANT A
TENANT CONTROL PLANE
CLUMSY TENANT B
TENANT CONTROL PLANE
CONTROL PLANE
MALICIOUS TENANT C
TENANT CONTROL PLANE
Your infra

Issues with Multi-Tenant Control Planes

- ✗ Clumsy Clients
- ✗ Access to Cluster Scoped Resources
- ✗ Ability to use off-the-shelf Cloud Native Tools

Issues with Multi-Tenant Control Planes

✔ Clumsy Clients

✗ Access to Cluster Scoped Resources

✗ Ability to use off-the-shelf Cloud Native Tools

Issues with Multi-Tenant Control Planes

✔ Clumsy Clients

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✗ Ability to use off-the-shelf Cloud Native Tools

Issues with Multi-Tenant Control Planes

- ✔ Clumsy Clients
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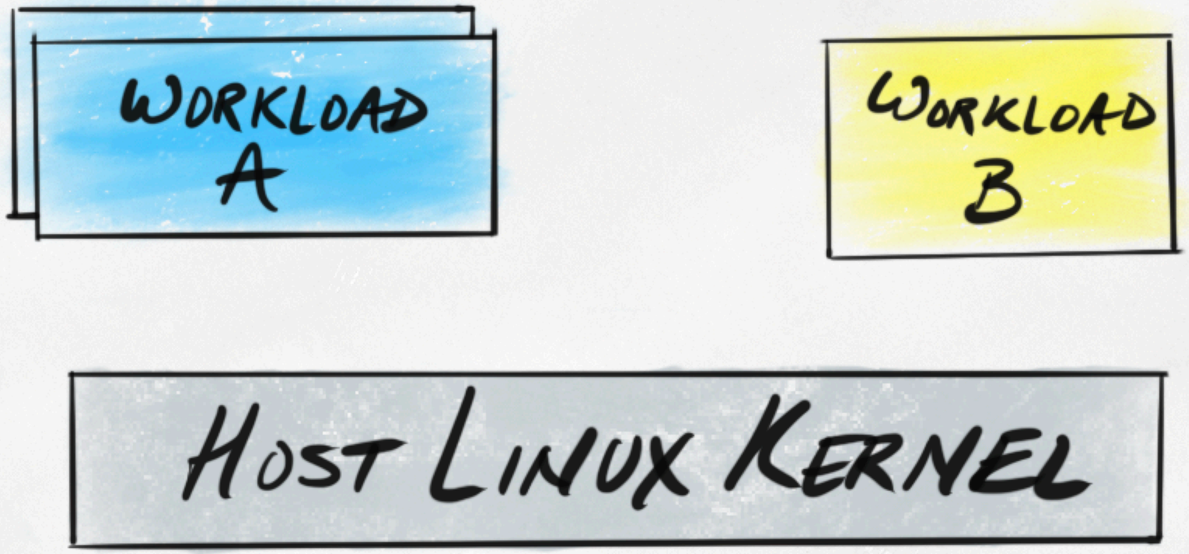
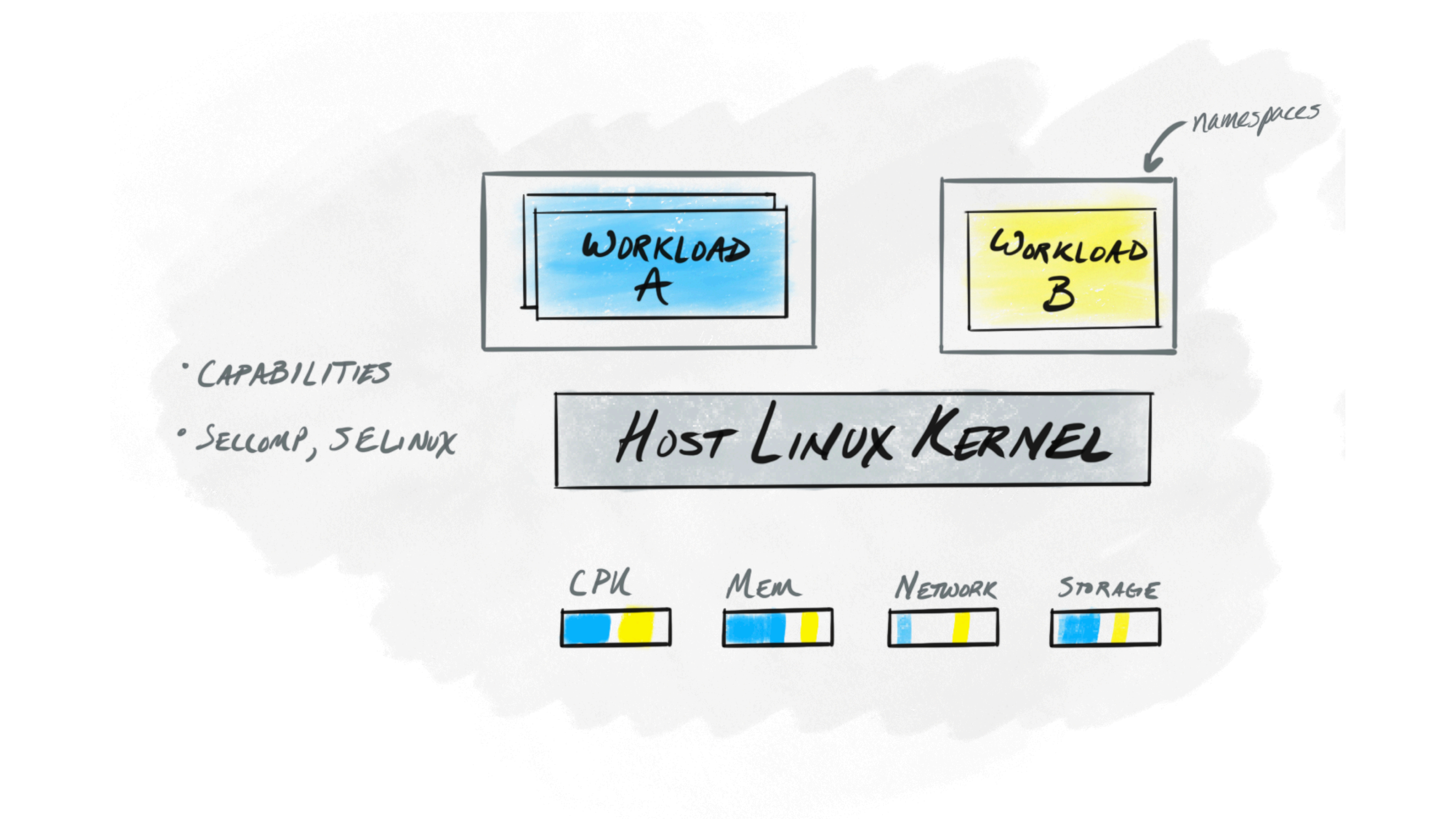
- ✔ Ability to use off-the-shelf Cloud Native Tools

Workload isolation


WORKLOAD A
WORKLOAD B
HOST LINUX KERNEL


namespaces
WORKLOAD A
WORKLOAD B
• CAPABILITIES
• SECCOMP, SELINUX
HOST LINUX KERNEL
CPU
MEM
NETWORK
STORAGE

Mutually untrusting tenants

Securing the data plane: options

- Don’t provide extra isolation
- Create node pools for each tenant
- Provide stronger workload isolation

Securing the data plane: options

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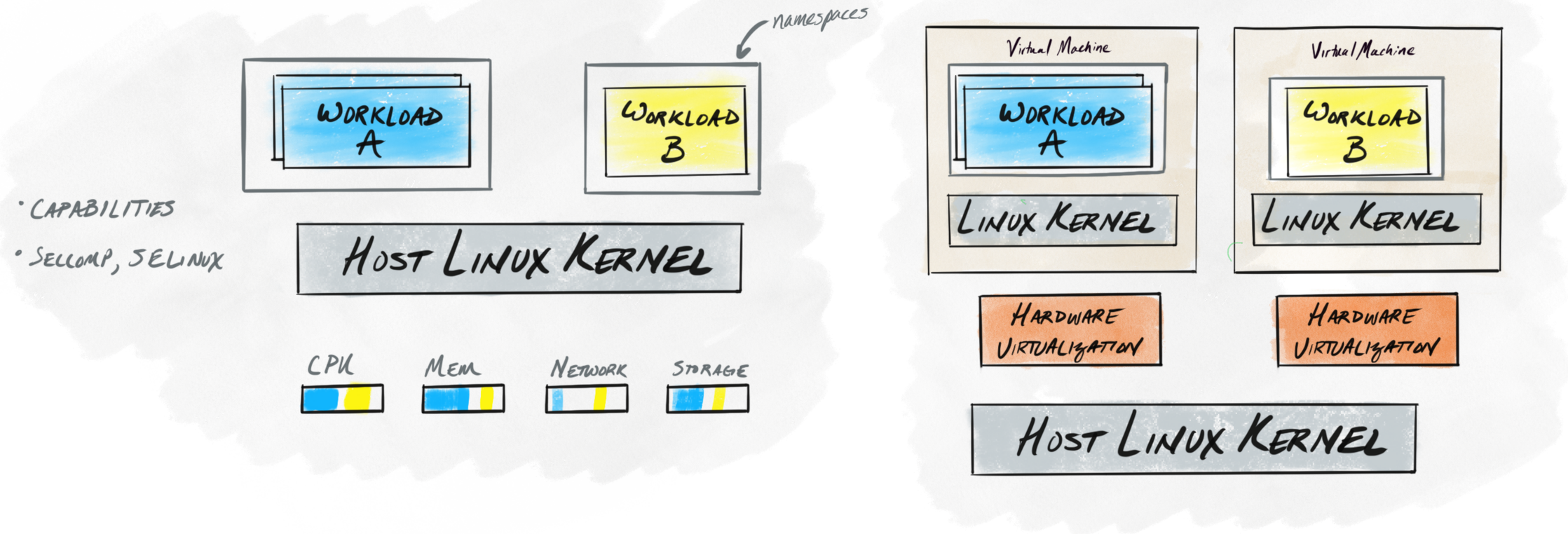
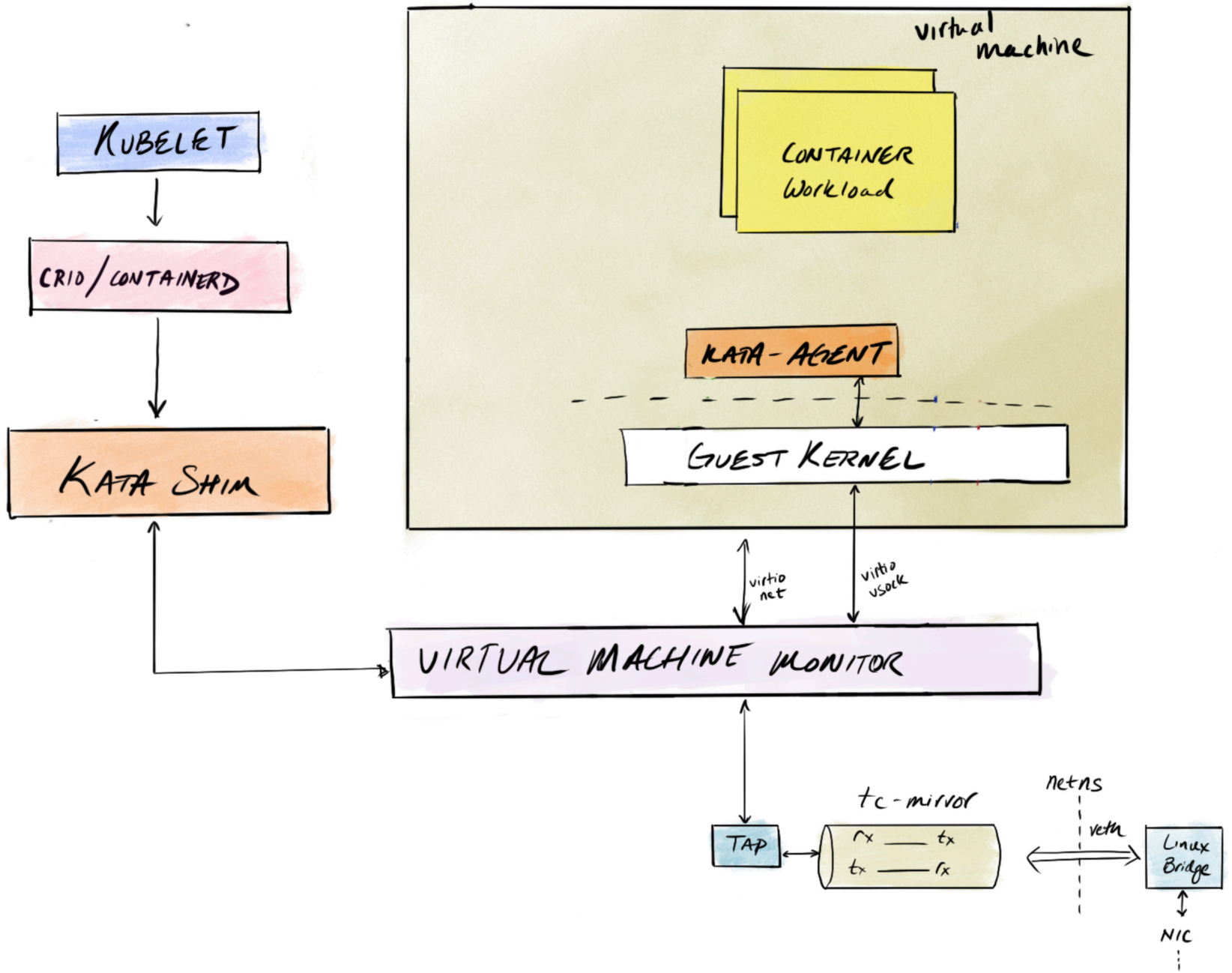
✗ Create node pools for each tenant

✔ Provide stronger workload isolation

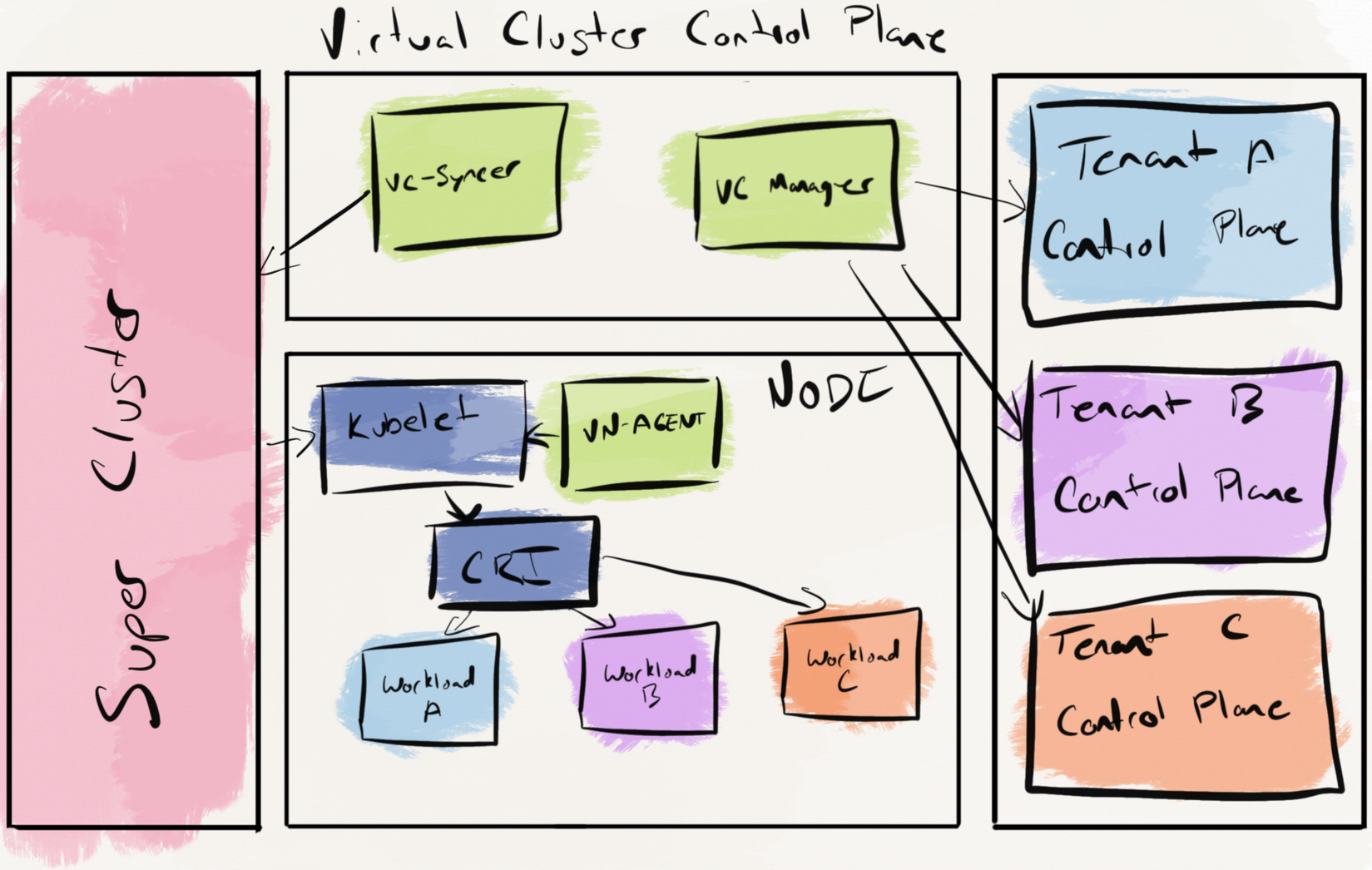
Sandboxed Runtimes

Sandboxed Runtimes


namespaces
WORKLOAD A
WORKLOAD B
• CAPABILITIES
• SECCOMP, SELINUX
HOST LINUX KERNEL
CPU
MEM
NETWORK
STORAGE
Virtual Machine
WORKLOAD A
LINUX KERNEL
Virtual Machine
WORKLOAD B
LINUX KERNEL
HARDWARE VIRTUALIZATION
HARDWARE VIRTUALIZATION
HOST LINUX KERNEL


virtual machine
KUBELET
CONTAINER Workload
CRIO / CONTAINERD
KATA-AGENT
KATA SHIM
GUEST KERNEL
virtio net
virtio vsock
VIRTUAL MACHINE MONITOR
tc-mirror
netns
TAP
rx
tx
tx
rx
veth
Linux Bridge
NIC

VirtualCluster Service Networking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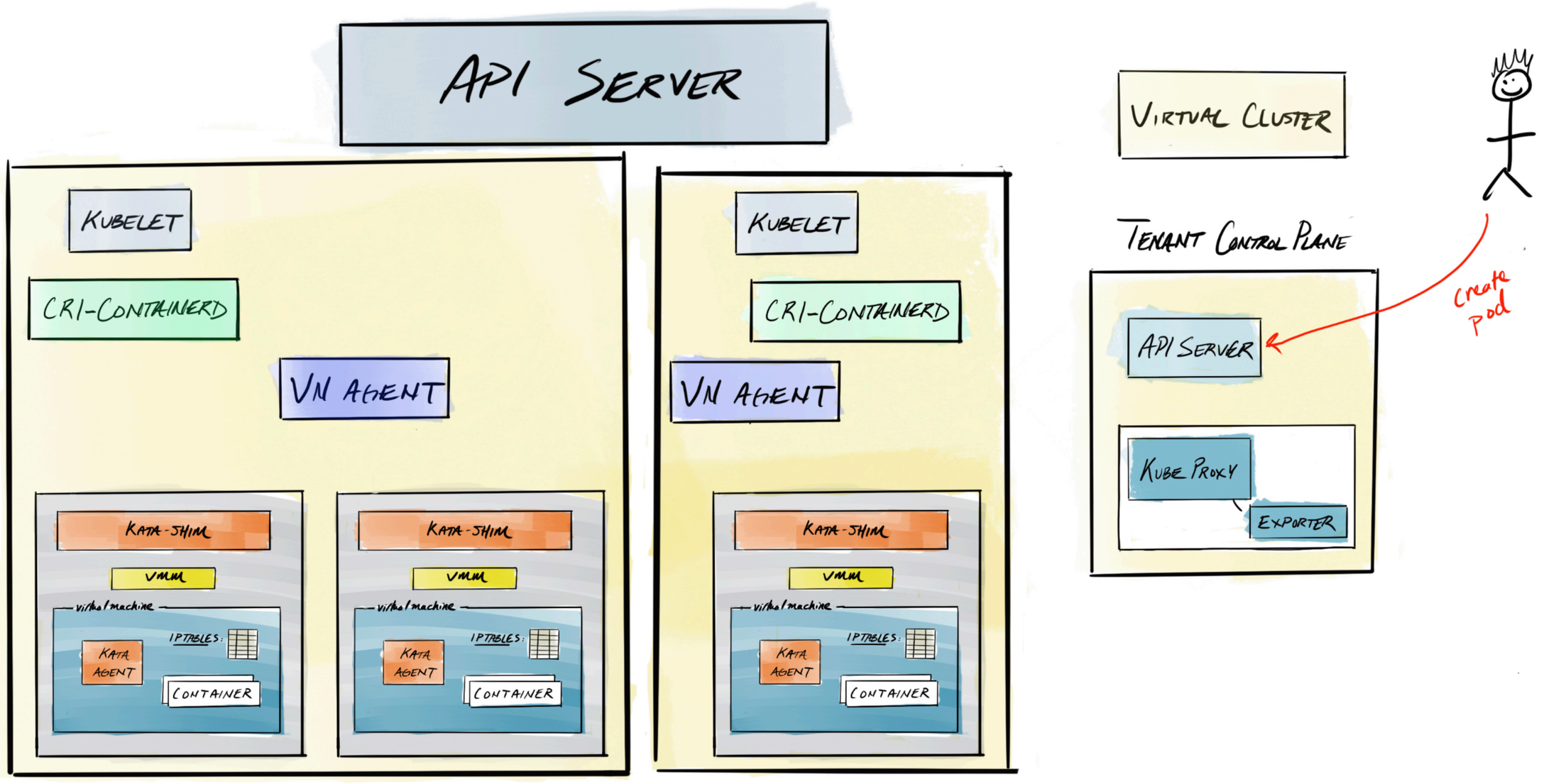
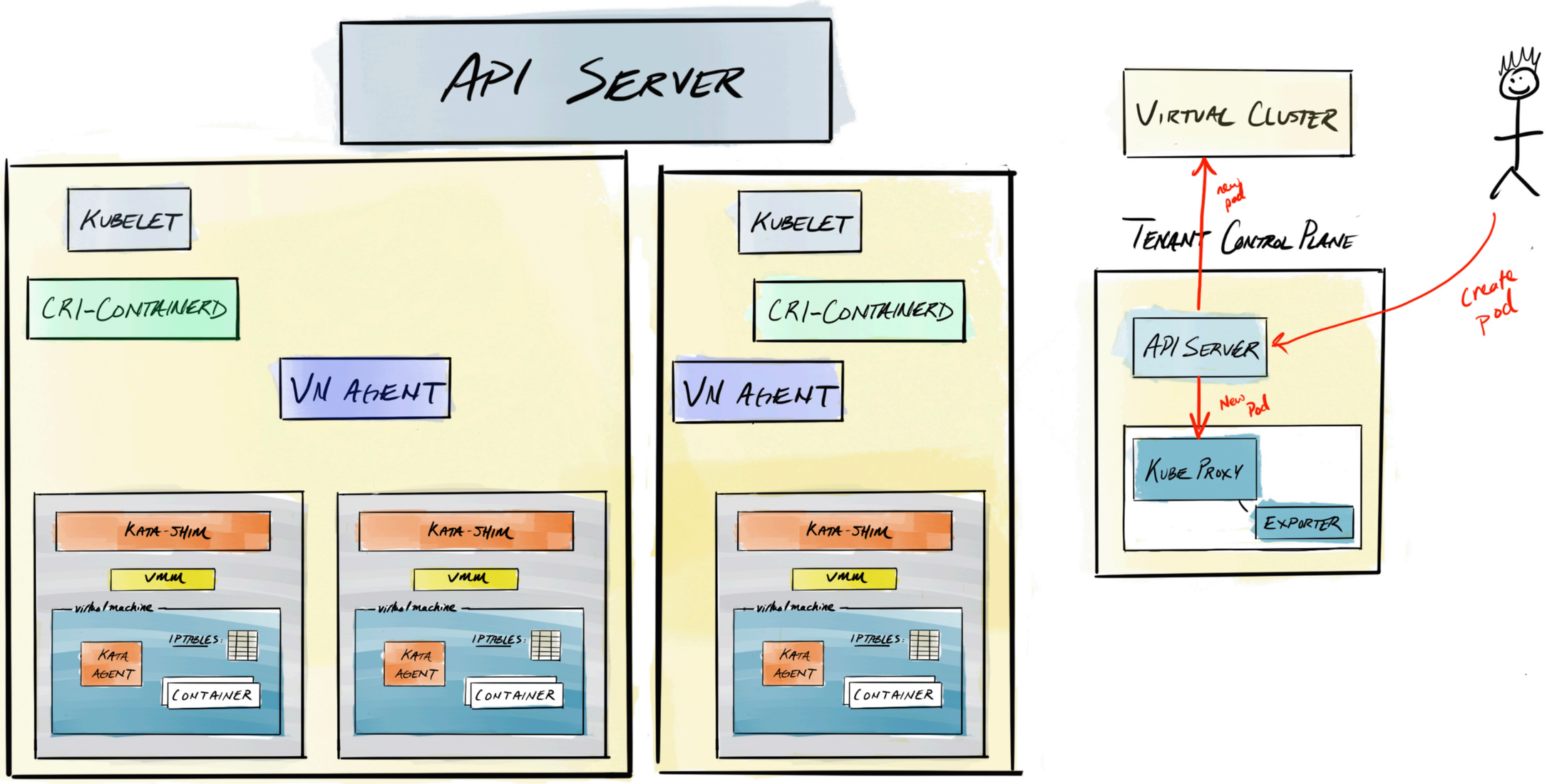
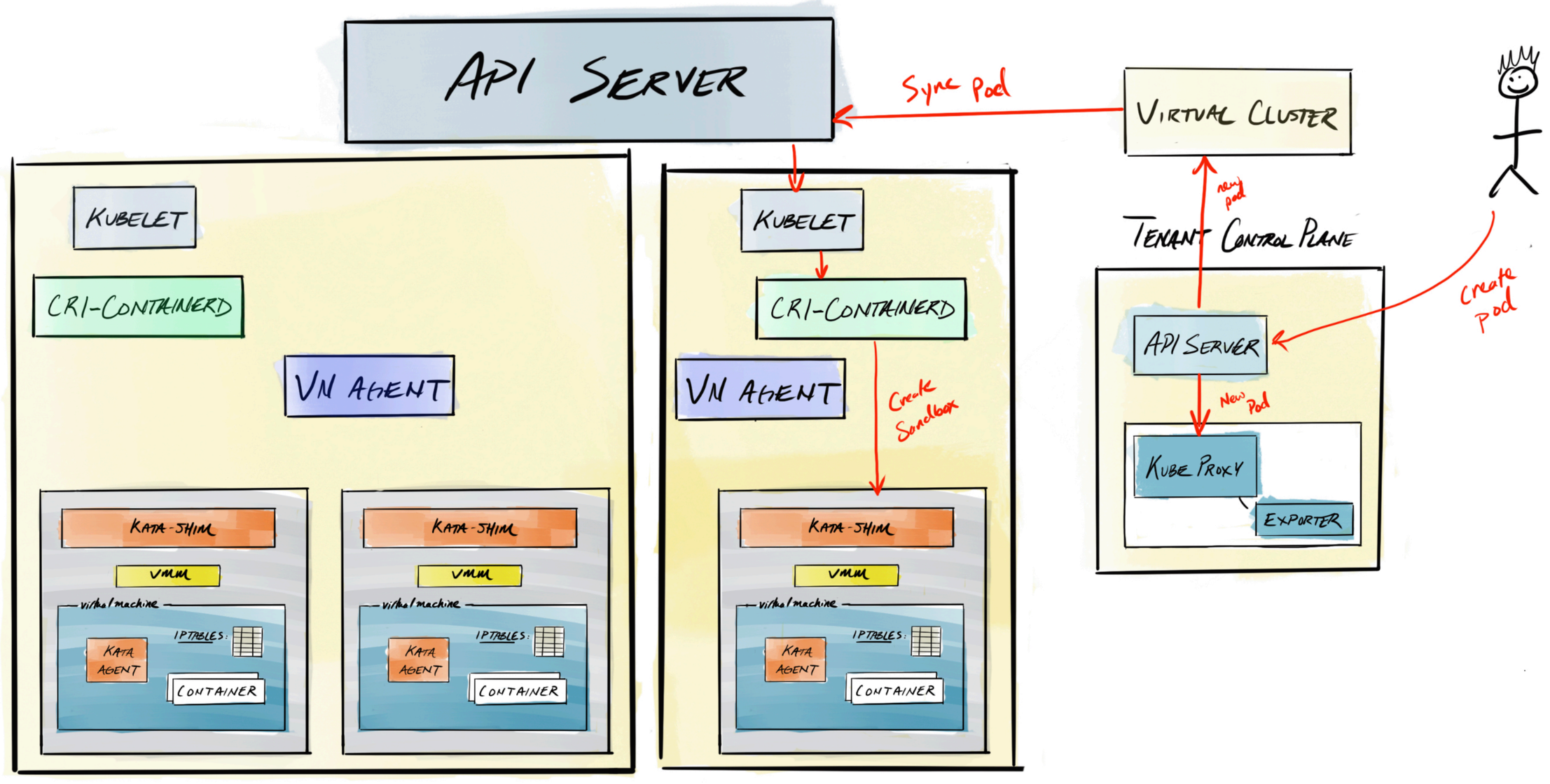
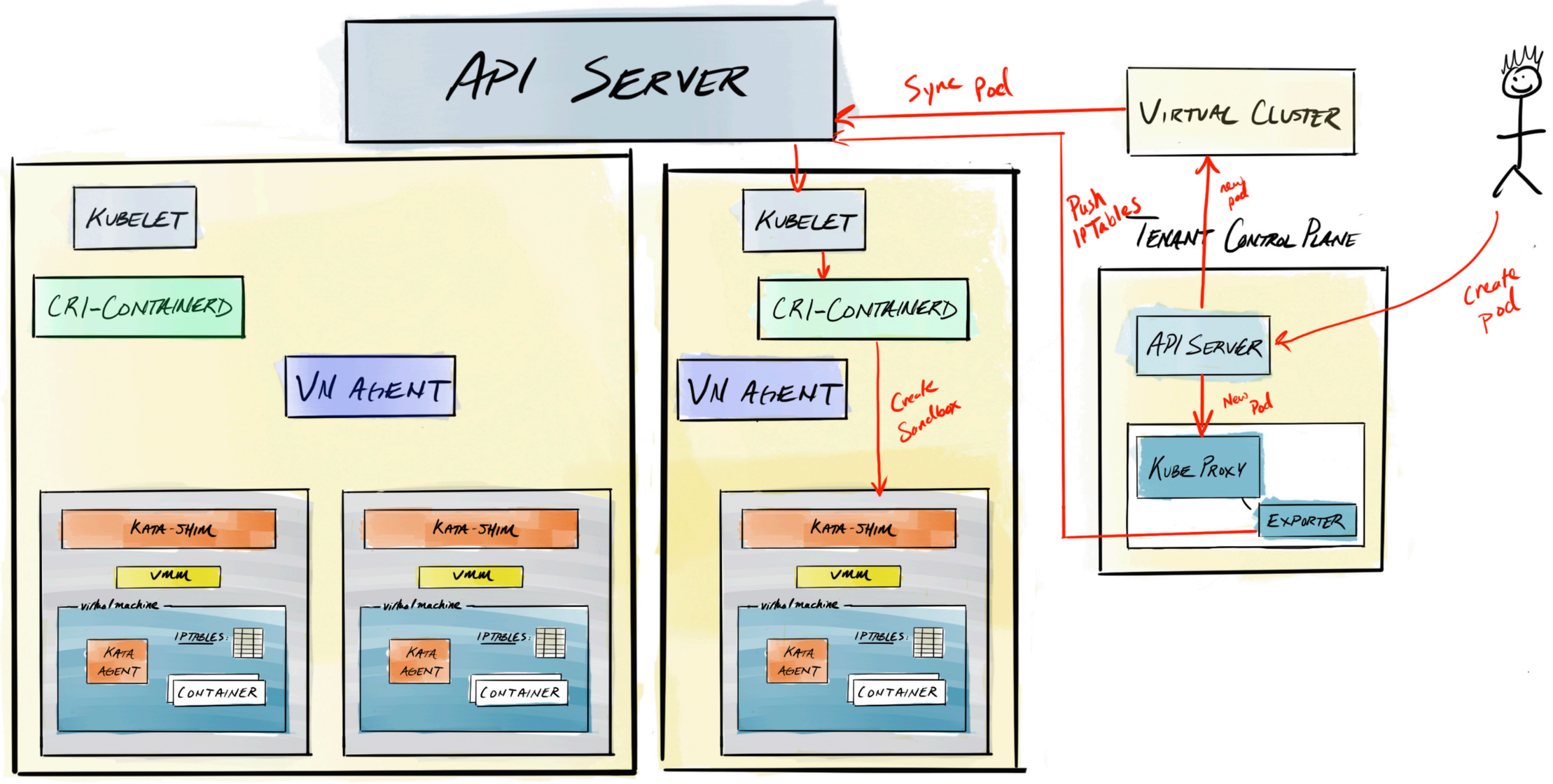

API SERVER
KUBELET
CRI-CONTAINERD
VN AGENT
KATA-SHIM
VMM
virtual machine
KATA AGENT
IPTABLES
CONTAINER
KUBELET
CRI-CONTAINERD
VN AGENT
KATA-SHIM
VMM
virtual machine
KATA AGENT
IPTABLES
CONTAINER
KATA-SHIM
VMM
virtual machine
KATA AGENT
IPTABLES
CONTAINER
VIRTUAL CLUSTER
TENANT CONTROL PLANE
API SERVER
KUBE PROXY
EXPORTER
create pod


API SERVER
KUBELET
CRI-CONTAINERD
VN AGENT
KATA-SHIM
VMM
virtual machine
IPTABLES:
KATA AGENT
CONTAINER
KUBELET
CRI-CONTAINERD
VN AGENT
KATA-SHIM
VMM
virtual machine
IPTABLES:
KATA AGENT
CONTAINER
KATA-SHIM
VMM
virtual machine
IPTABLES:
KATA AGENT
CONTAINER
VIRTUAL CLUSTER
new pod
TENANT CONTROL PLANE
API SERVER
New Pod
KUBE PROXY
EXPORTER
create Pod


API SERVER
Sync Pod
VIRTUAL CLUSTER
KUBELET
CRI-CONTAINERD
VN AGENT
KATA-SHIM
VMM
virtual machine
IPTABLES
KATA AGENT
CONTAINER
KUBELET
CRI-CONTAINERD
VN AGENT
Create Sandbox
KATA-SHIM
VMM
virtual machine
IPTABLES
KATA AGENT
CONTAINER
new pod
TENANT CONTROL PLANE
API SERVER
New Pod
KUBE PROXY
EXPORTER
create pod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Sync Pod
VIRTUAL CLUSTER
KUBELET
CRI-CONTAINERD
VN AGENT
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Create Sandbox
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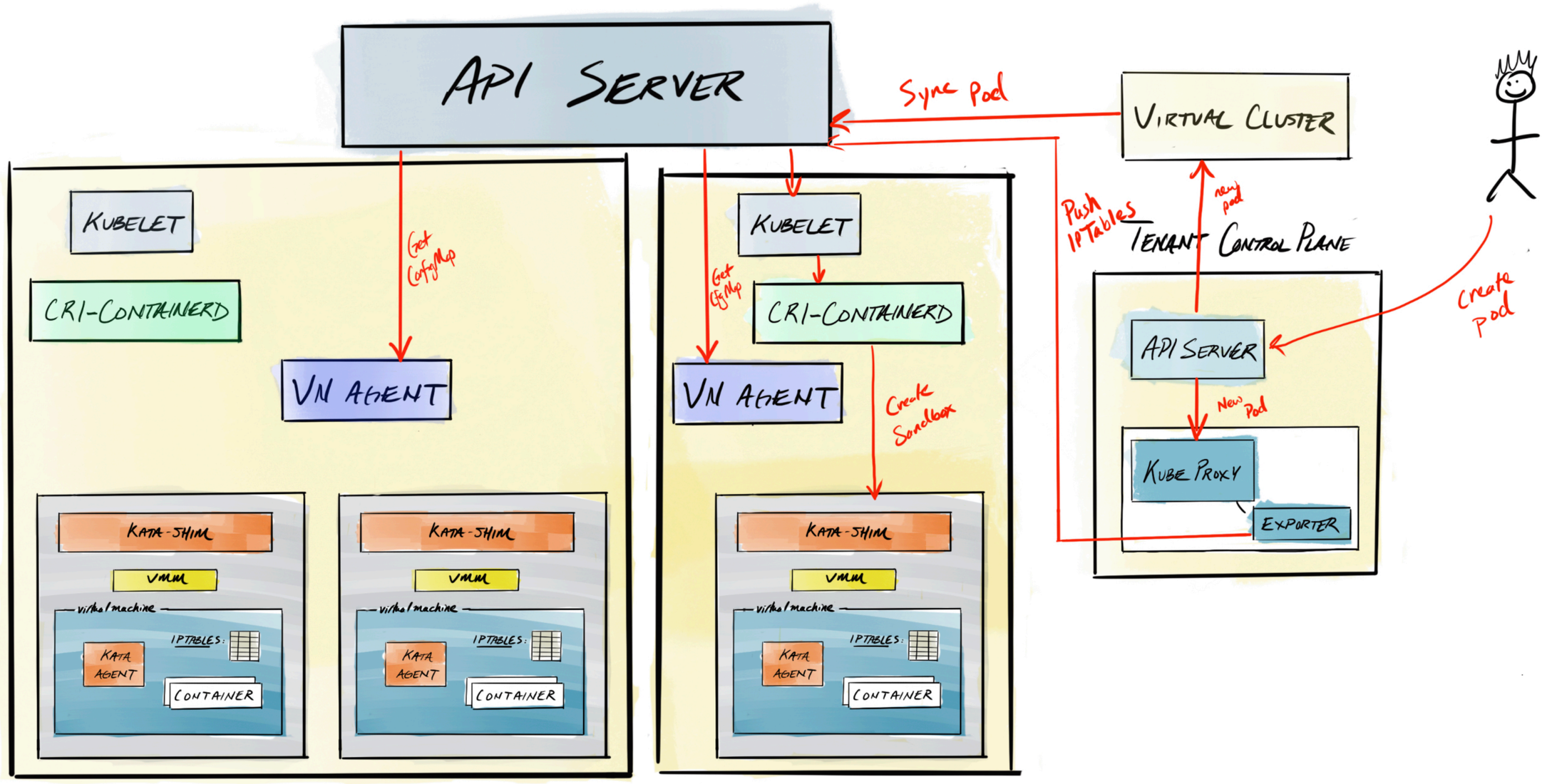
CONTAINER
Push IPTables
new pod
TENANT CONTROL PLANE
API SERVER
New Pod
KUBE PROXY
EXPORTER
create pod


API SERVER
Sync Pod
VIRTUAL CLUSTER
KUBELET
CRI-CONTAINERD
Get ConfigMap
VN AGENT
KUBELET
CRI-CONTAINERD
Get CfgMap
VN AGENT
Create Sandbox
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API SERVER
New Pod
KUBE PROXY
EXPORTER
Create Pod
KATA-SHIM
VMM
virtual machine
IPTABLES:
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CONTAINER
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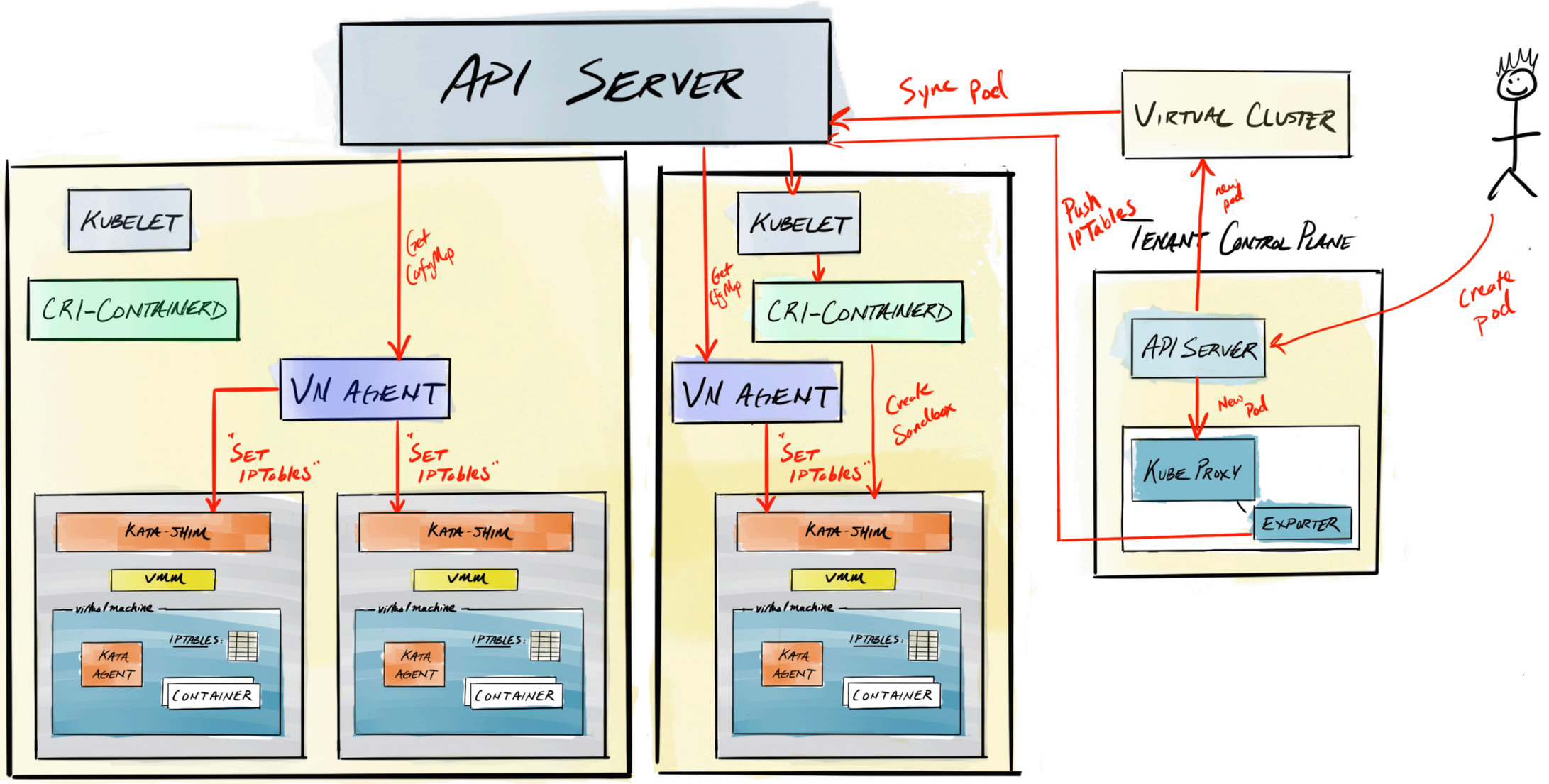
IPTABLES:
KATA AGENT
CONTAINER


API SERVER
Sync Pod
VIRTUAL CLUSTER
KUBELET
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Get CofigMap
VN AGENT
"SET IPTABLES"
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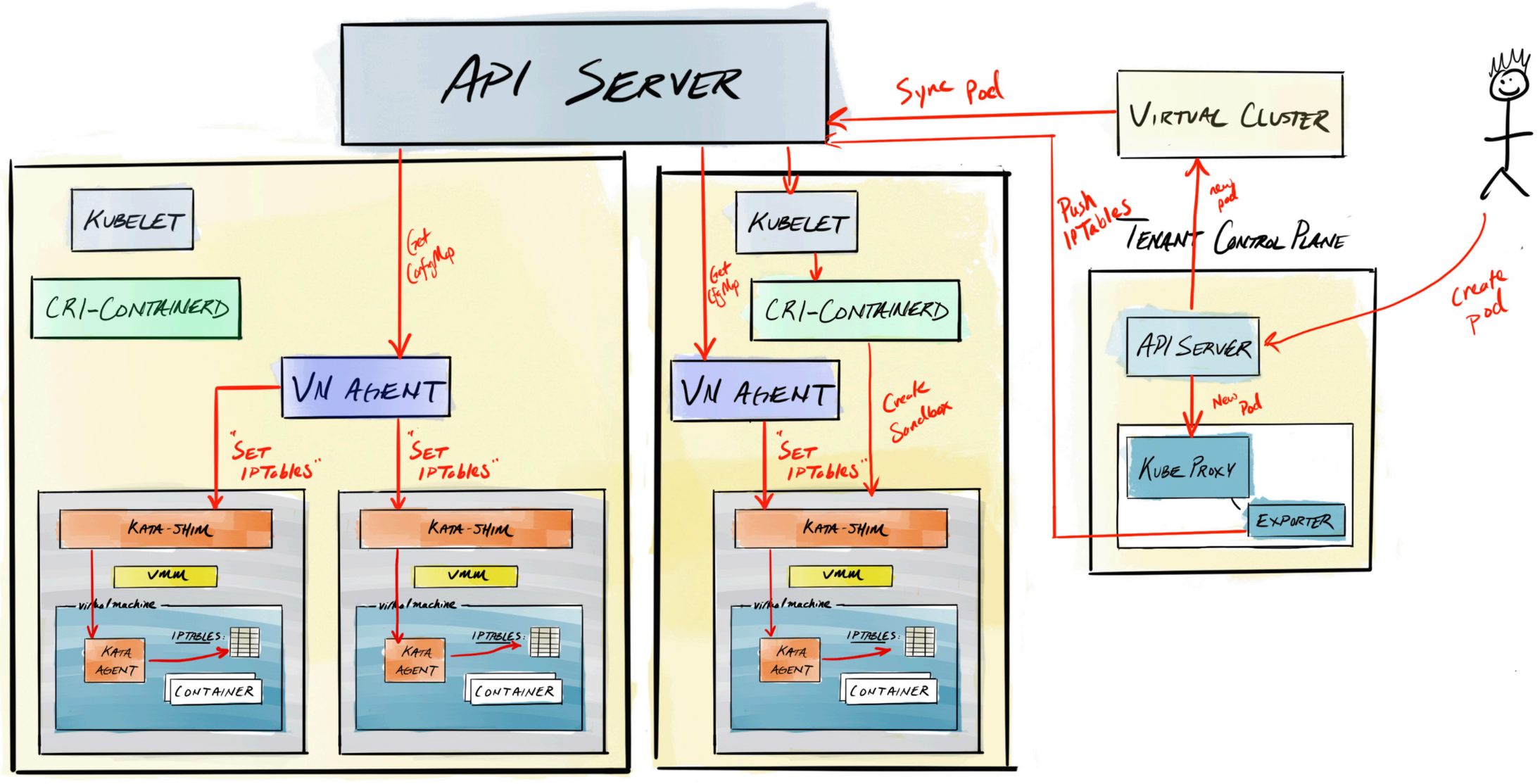
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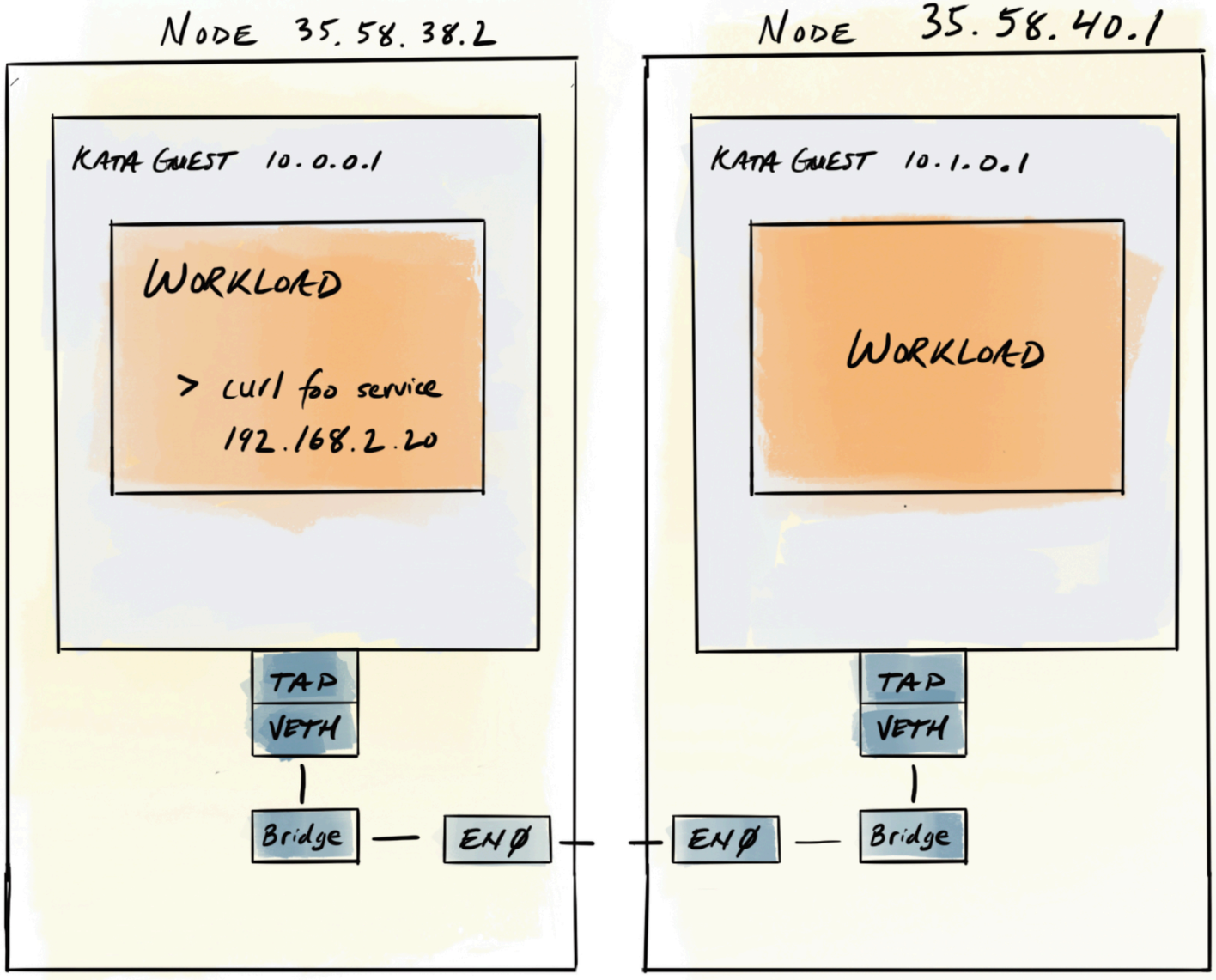
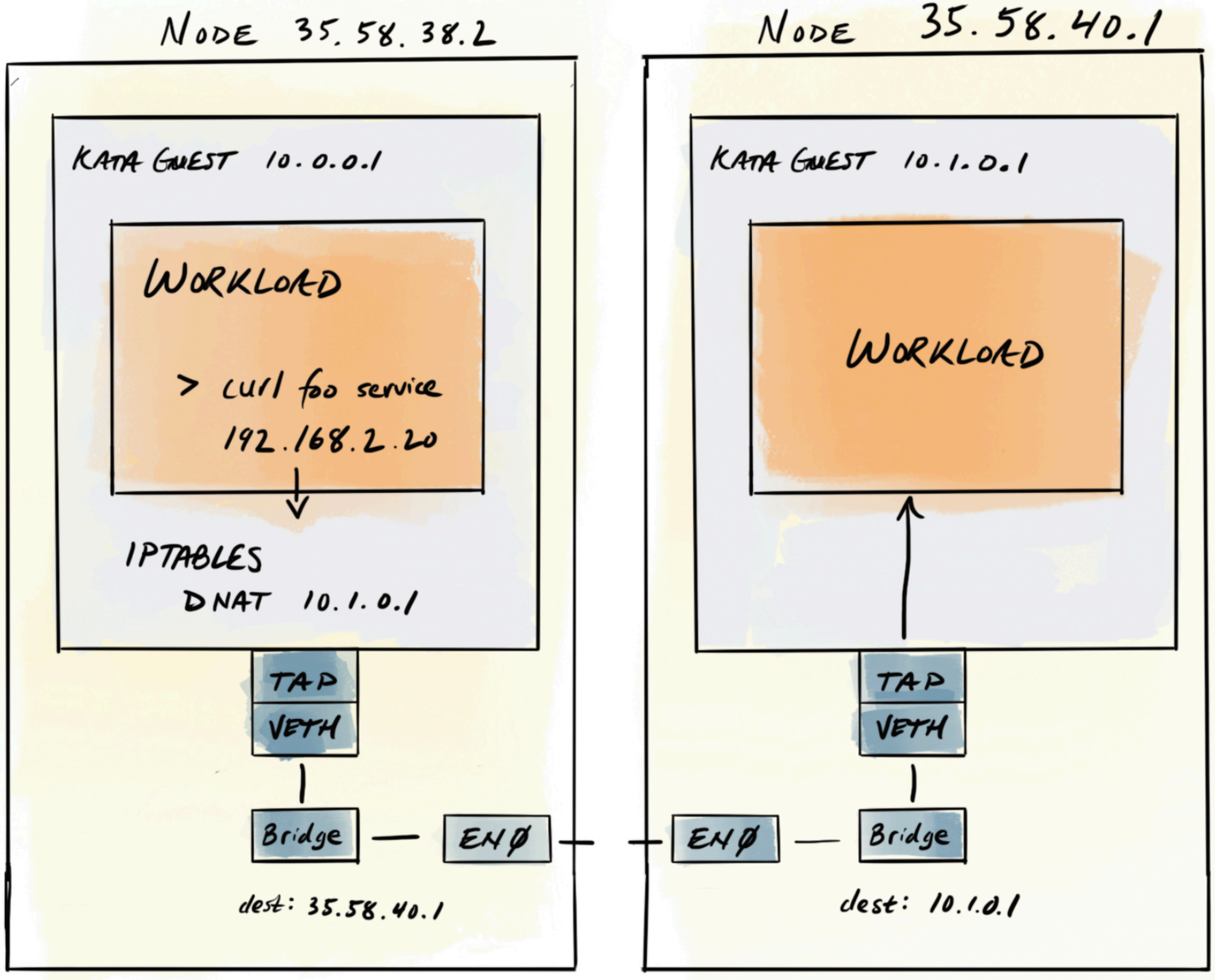
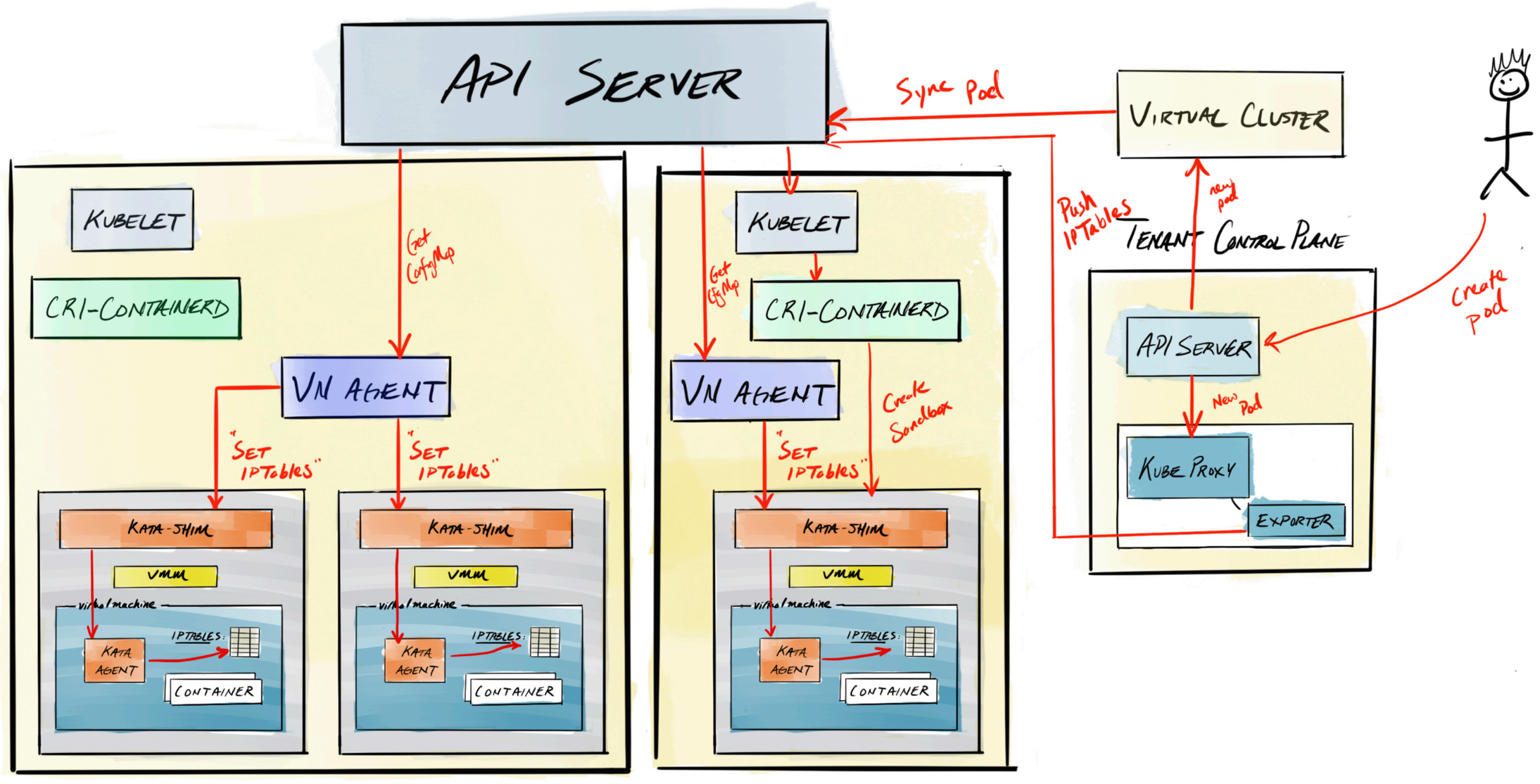

NODE 35.58.38.2
KATA GUEST 10.0.0.1
WORKLOAD
> curl foo service
192.168.2.20
TAP
VETH
Bridge
ENØ
NODE 35.58.40.1
KATA GUEST 10.1.0.1
WORKLOAD
ENØ
TAP
VETH
Bridge


NODE 35.58.38.2
KATA GUEST 10.0.0.1
WORKLOAD
> curl foo service
192.168.2.20
IPTABLES
DNAT 10.1.0.1
TAP
VETH
Bridge
ENØ
dest: 35.58.40.1
NODE 35.58.40.1
KATA GUEST 10.1.0.1
WORKLOAD
TAP
VETH
ENØ
Bridge
dest: 10.1.0.1

Demo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"SET IPTABLES"
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API SERVER
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EXPORTER
create Pod

Future

Integration with KPNG

“New Kubernetes NG Proxy” - https://sigs.k8s.io/kpng

Separate VPCs/Overlays Per VirtualCluster.

Feedback

Thanks!