An Open Architecture for an Infinitely Scalable C2 system using Docker, Kubernetes, and Istio

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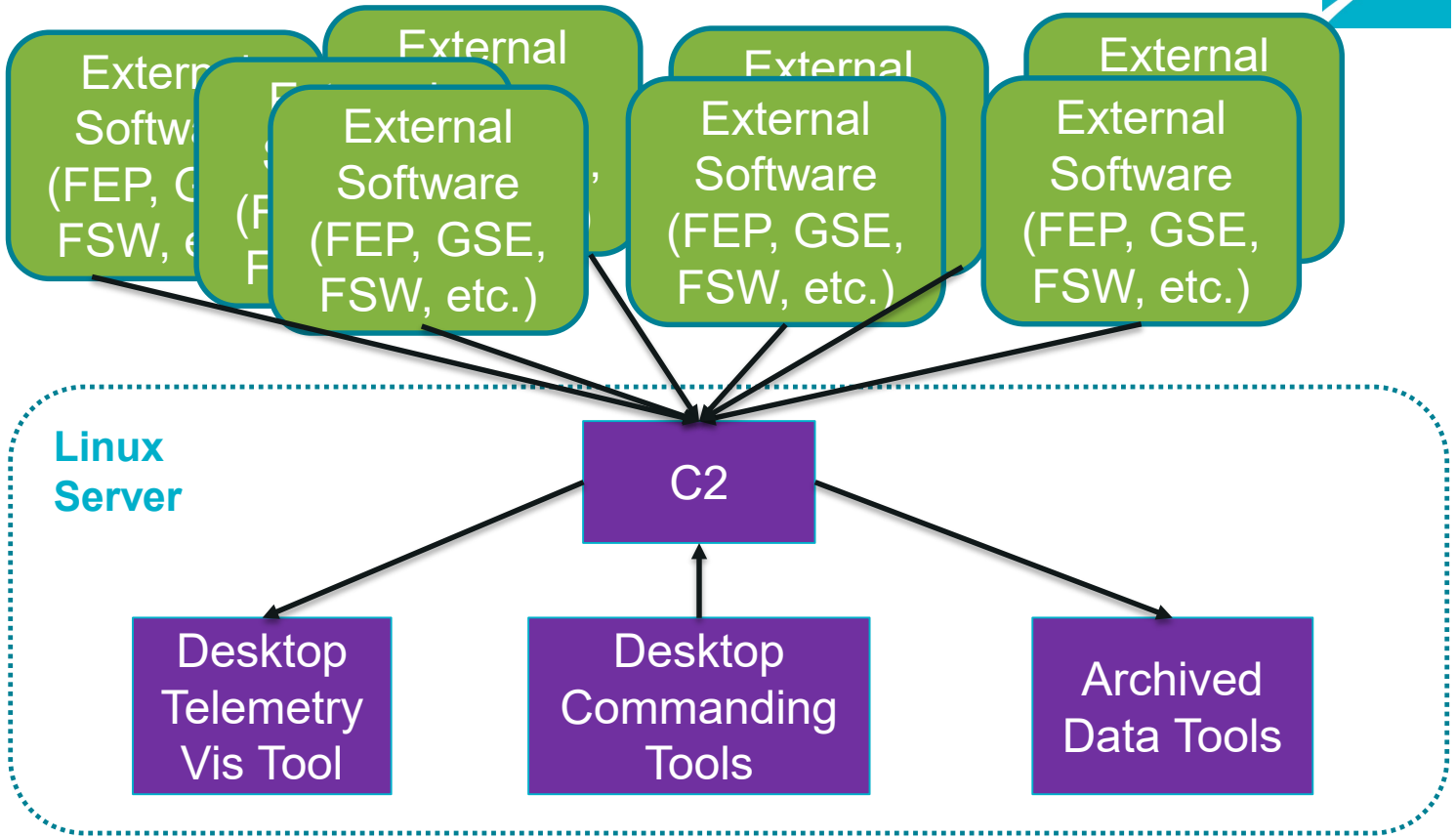
The Problem


External Software (FEP, GSE, FSW, etc.)
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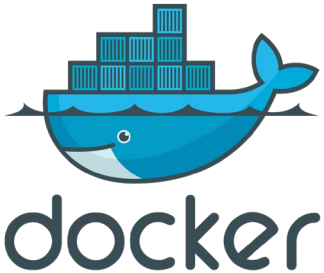
Linux Server
C2
Desktop Telemetry Vis Tool
Desktop Commanding Tools
Archived Data Tools
Key:
Linux Process
External

The Solution: Infrastructure

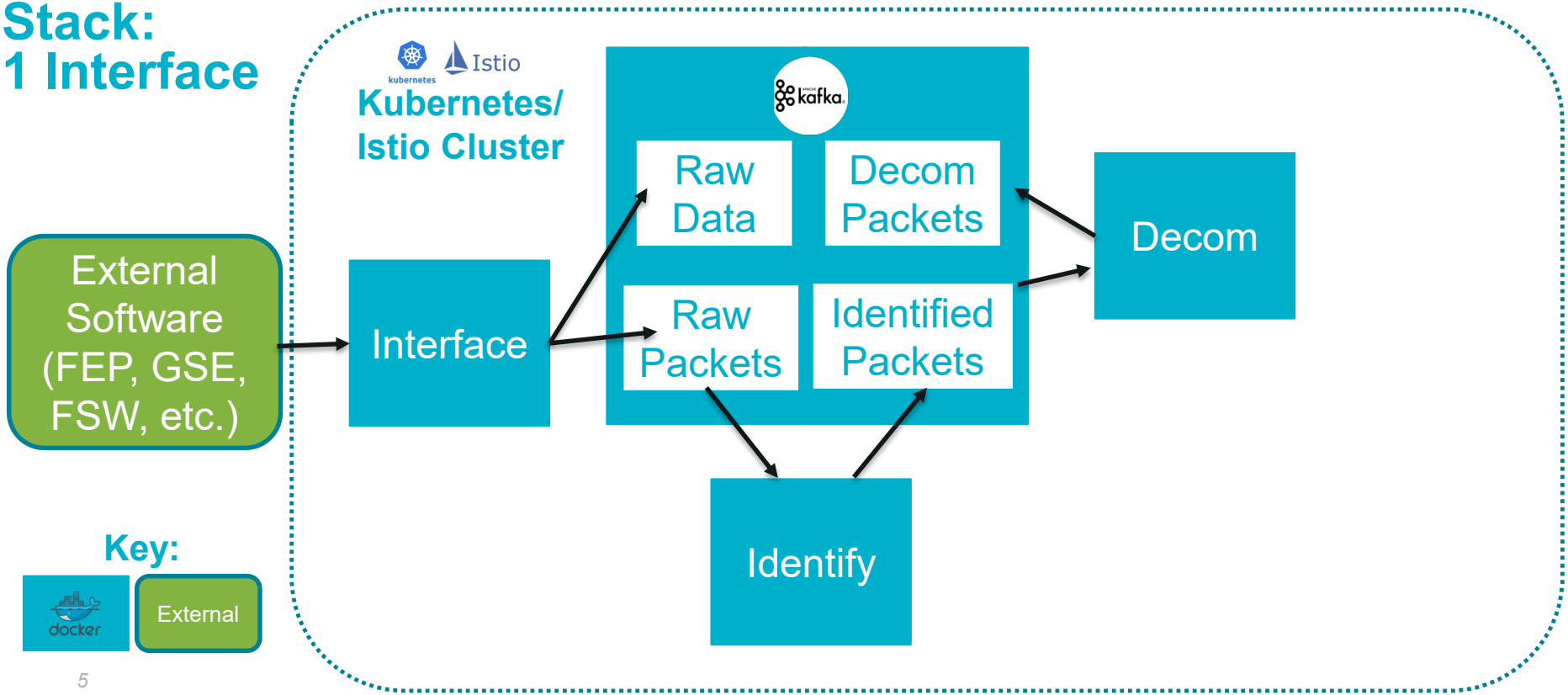
- **Docker** – Builds and runs containers – Ideally one process per container
- **Kubernetes** – Organizes and orchestrates containers in “pods” – Provides networking, process monitoring, DNS, replication, and autoscaling
- **Istio** – Adds a proxy server to every pod that all network traffic goes through – Allows mTLS without any application changes, detailed built in monitoring metrics, and strict security rule enforcement



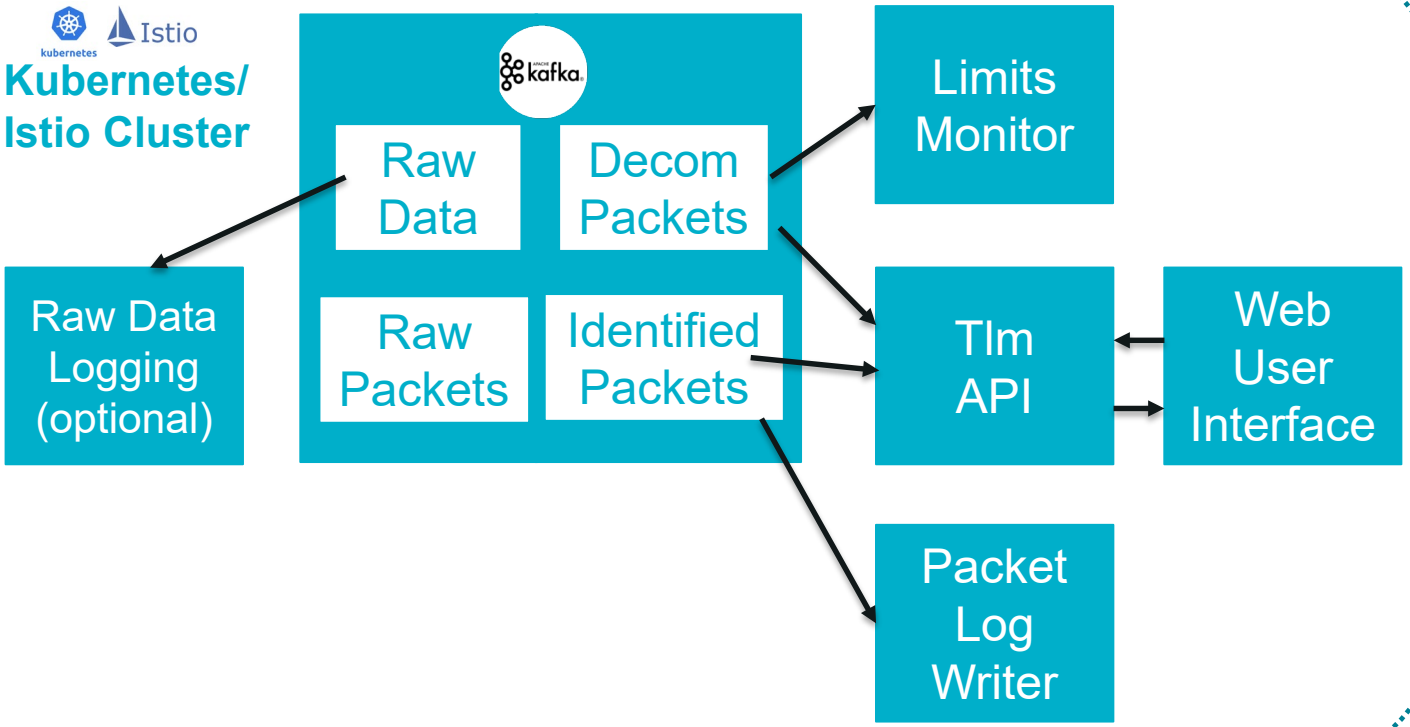
Event Driven Asynchronous Comm

- Streaming Message Broker
  - Provides a common asynchronous interface between the containers that make up the C2 system
  - Scales easily to new satellites by simply adding more containers
  - High performance from a simple internal architecture – streams are basically just files
  - Primarily used to receive streaming telemetry

Realtime Telemetry Microservices Stack: 1 Interface



Realtime Telemetry Microservices Stack: 1 Interface



Key:

docker External

Architecture Break #1: Docker

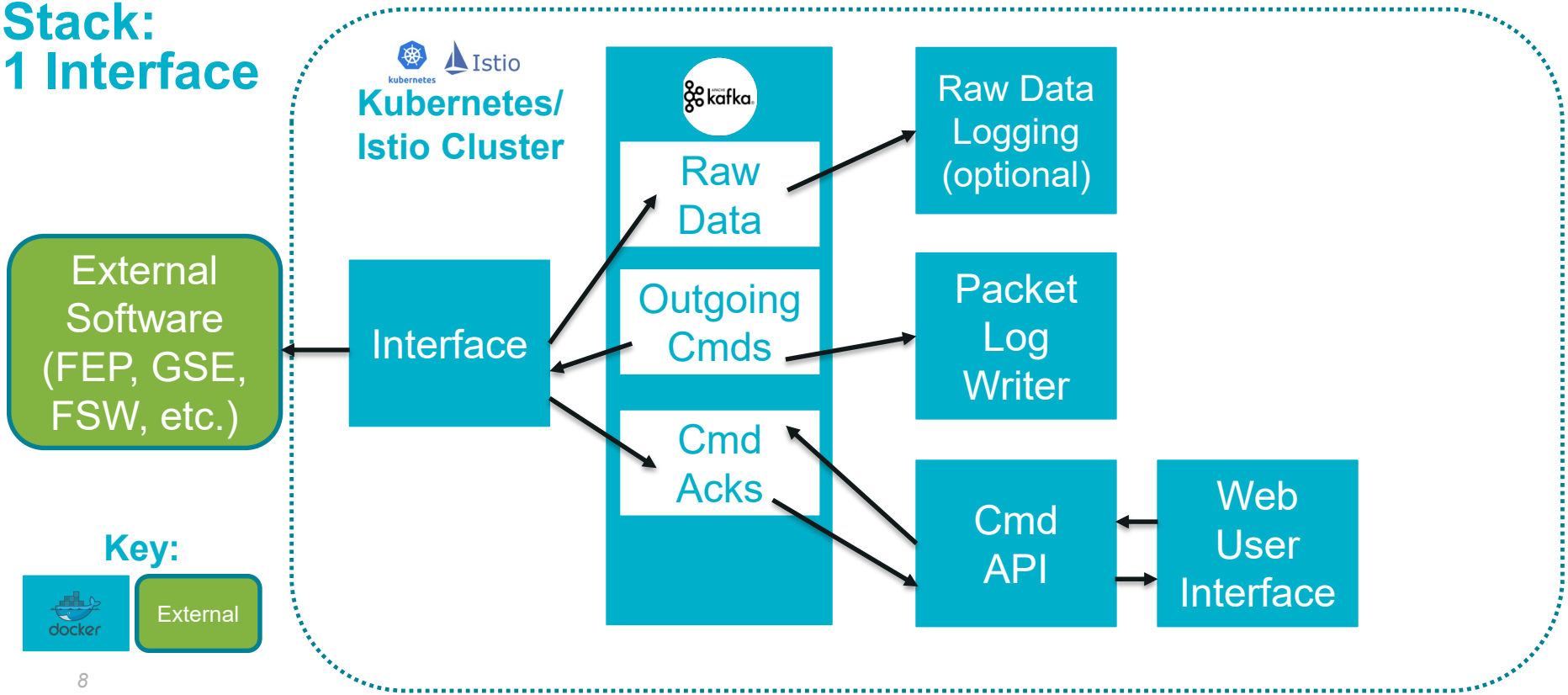
- Processes inside a docker container (1):

```
root@243ab21658d6: /
root@243ab21658d6:/# ps -e
  PID TTY          TIME CMD
    1 pts/0    00:00:00 bash
   10 pts/0    00:00:00 ps
root@243ab21658d6:/#
```

- Processes inside a virtual machine (280!):

```
27413 ?        00:00:00 unity-fallback-
27417 ?        00:00:00 polkit-gnome-au
27452 ?        00:00:42 compiz
27475 ?        00:00:00 evolution-calen
27486 ?        00:00:00 gvfs-udisks2-vo
27505 ?        00:00:00 evolution-calen
27516 ?        00:00:00 gvfs-gphoto2-vo
27517 ?        00:00:00 evolution-addre
27525 ?        00:00:00 gvfs-mtp-volume
27533 ?        00:00:00 gvfs-afc-volume
27536 ?        00:00:00 evolution-addre
27549 ?        00:00:00 gvfs-goa-volume
27588 ?        00:00:00 gvfsd-metadata
27621 ?        00:00:00 kworker/u2:1
27625 ?        00:00:00 gvfsd-trash
27634 ?        00:00:00 dbus-launch
27635 ?        00:00:00 dbus-daemon
27637 ?        00:00:00 notify-osd
27641 ?        00:00:00 gvfsd
27651 ?        00:00:00 gnome-screensav
27662 ?        00:00:00 sh
27666 ?        00:00:00 zeitgeist-daemo
27674 ?        00:00:00 zeitgeist-fts
27675 ?        00:00:00 zeitgeist-datah
27689 ?        00:00:01 gnome-terminal-
27696 ?        00:00:00 gconfd-2
27708 pts/36   00:00:00 bash
27929 ?        00:00:00 update-notifier
27940 pts/36   00:00:04 ruby
27982 ?        00:00:00 dhclient
28025 ?        00:00:00 kworker/0:3
28027 ?        00:00:00 kworker/0:4
28034 ?        00:00:00 deja-dup-monito
28057 pts/36   00:00:00 ps
29144 ?        00:00:00 systemd-udevd
31920 ?        00:00:00 kworker/0:1
31956 ?        00:00:00 apt.systemd.dai
32234 ?        00:34:18 unattended-upgr
32244 ?        00:00:02 gnome-terminal-
32251 pts/4    00:00:00 bash
32439 ?        00:00:02 postgres
32441 ?        00:00:00 postgres
32442 ?        00:00:02 postgres
32443 ?        00:00:02 postgres
32444 ?        00:00:01 postgres
32445 ?        00:00:01 postgres
32574 pts/4    00:00:00 su
32575 pts/4    00:00:00 bash
32599 pts/17   00:00:00 bash
rubytest@rmelton-VirtualBox:~$
```

Realtime Command Microservices Stack: 1 Interface



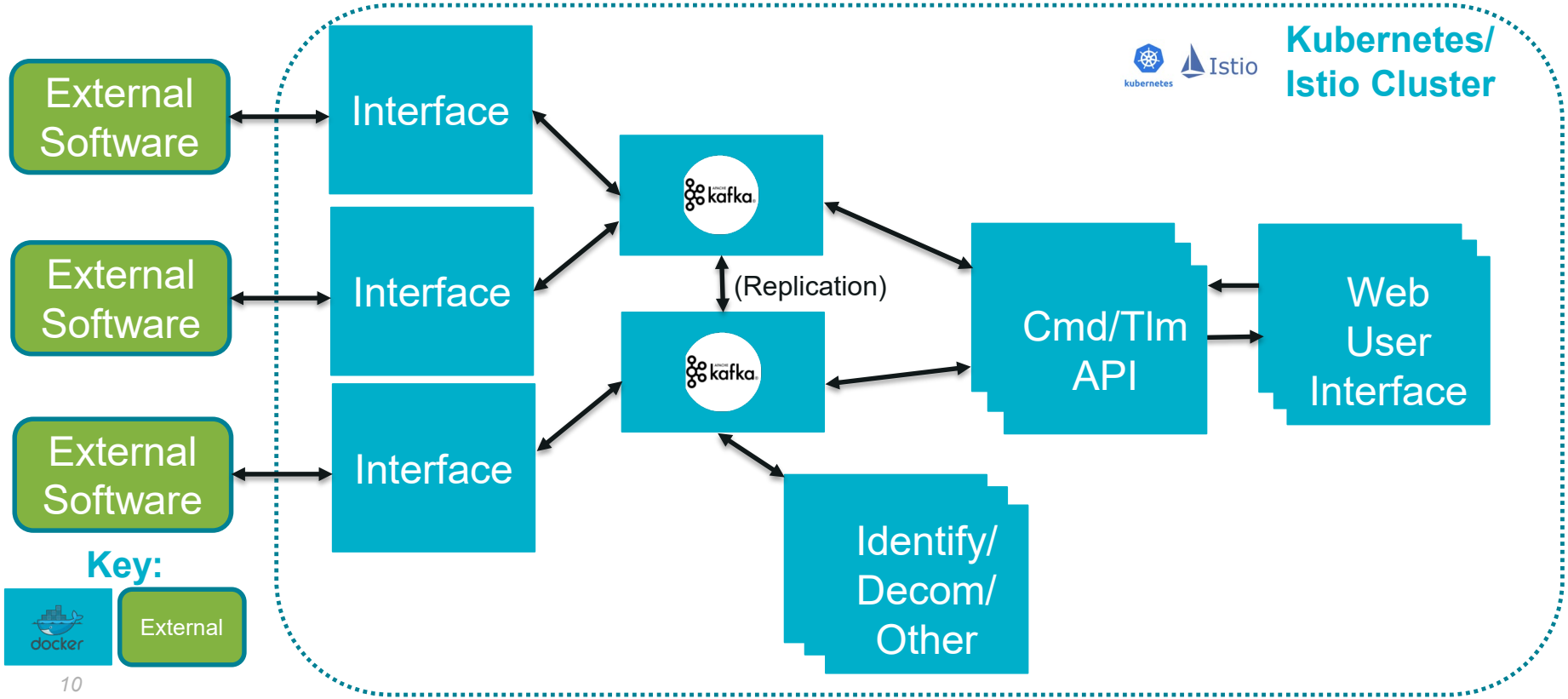
Architecture Break #2: Kubernetes

- Config file to deploy a replicated app in Kubernetes:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-deployment
  labels:
    app: nginx
spec:
  replicas: 3
  selector:
    matchLabels:
      app: nginx
template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - name: nginx
        image: nginx:1.7.9
        ports:
        - containerPort: 80
---
apiVersion: v1
kind: Service
metadata:
  name: nginx-service
spec:
  selector:
    app: nginx
  ports:
    - protocol: TCP
      port: 80
      targetPort: 80
```

kubernetes

Cmd/Tlm Microservices Stack: Infinite



Architecture Break #3: Istio

- Installing Istio with mTLS in auto mode:

```
istioctl manifest apply --set profile=demo \
  --set values.global.mtls.auto=true \
  --set values.global.mtls.enabled=false
```

Summary

- Docker containers hold each microservice
- Kubernetes manages orchestrating and scaling microservices
- Istio provides encrypted communications between all microservices, and useful metrics
- Kafka provides an easily scalable message bus platform
- C2 architecture can be scaled to any number of interfaces, by adding more microservices and Kafka nodes when necessary

Questions

- Keep up with C2 at Ball at: cosmosrb.com/news

Backup Slides

Scaling

- As additional satellites and ground support hardware are added, new Kafka nodes can be added to continually scale
- Microservices performing identification, decommutation, and packet logging can be created and assigned to one or more pieces of hardware as bandwidth dictates
- The overall Kubernetes cluster can be grown by adding additional hardware nodes at anytime. In cloud environments, this can be done on demand.
- Additional PostgresSQL databases for archiving can be added to support unique new sets of hardware. The API will handle querying the correct backend database.

Reliability

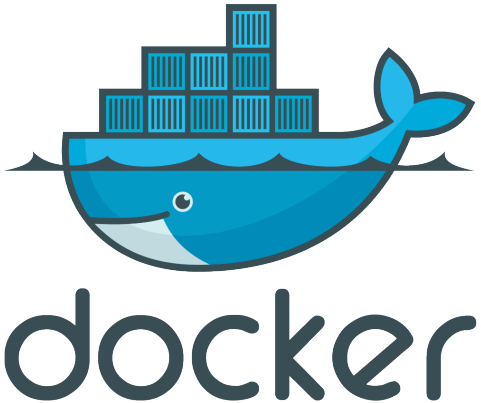
- Kafka data is replicated and any node can fail with automatic failover and no downtime
- Kubernetes will automatically respawn any pod that dies
- Postgres Database can be setup with master-master replication to support automatic failover

Security

- All internal C2 cluster data is encrypted and verified using mTLS as supported by Istio – This requires no changes to application code
- Istio policy ensures pods can only talk to other pods as required
- Ingress/Egress from the C2 cluster is secured by policy with only necessary access granted
- Kubernetes access is controlled by keys that are only available to admin users

Docker and Containers

- Like Virtual Machines But Better…
- Dockerfile
  - Text file captures the steps to build the container repeatably
- Lightweight
  - Starts in seconds
- Ideally only one process running in each container
- Contains only what is needed to run the single process



Kubernetes

- Orchestrates containers into groups called pods – starts them up and keeps them alive
- Provides an isolated network environment for the cluster and assigns them IP addresses / DNS names
- Provides load balancing for groups of containers
- Supports auto-scaling

kubernetes

Istio

- Adds a controlled proxy container to every pod
  - Enables Mutual TLS between pods with no changes to the application
  - Allows setting security constraints ie. Pod X can only talk to pod Y
  - Provides detailed built-in monitoring metrics, such as bandwidth in and out of each pod