Video Analytics in the Big & Fast Streaming Data Era

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Video Analytics Trends

1. City-wide surveillance deployments

2. Increasing camera resolutions

3. Structured data: Correlation & Smart cameras

4. Mobile handsets as sensors

5. Advanced Video Content Analysis (VCA)

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Motivations

- Video investigation in action
  - Hunting Criminal Zhou Kehua, China, 2012
  - Boston Marathon Bombing, USA, 2013
- Traditional approaches do not work
  - Challenges
  - Status quo

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Hunting Criminal Zhou in 2012

- 1000+ Policemen X 2 months.
- 300TB Surveillance videos
  - Equivalently **830,000 movies.** ☹
- Collecting the local video storages was challenging.
- Video analytics:
  - Face detection & recognition,
  - Video summarization, indexing , retrieval

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Boston Marathon Bombing in 2013

- 120 FBI Agents sorted through 13,000+ videos (10 TB's).
- Crowd sourcing videos on Internet examined by thousands of volunteers.
- Video analytics: "to compress video, pinpoint areas of interest, look for anomalies and find relevant details…"



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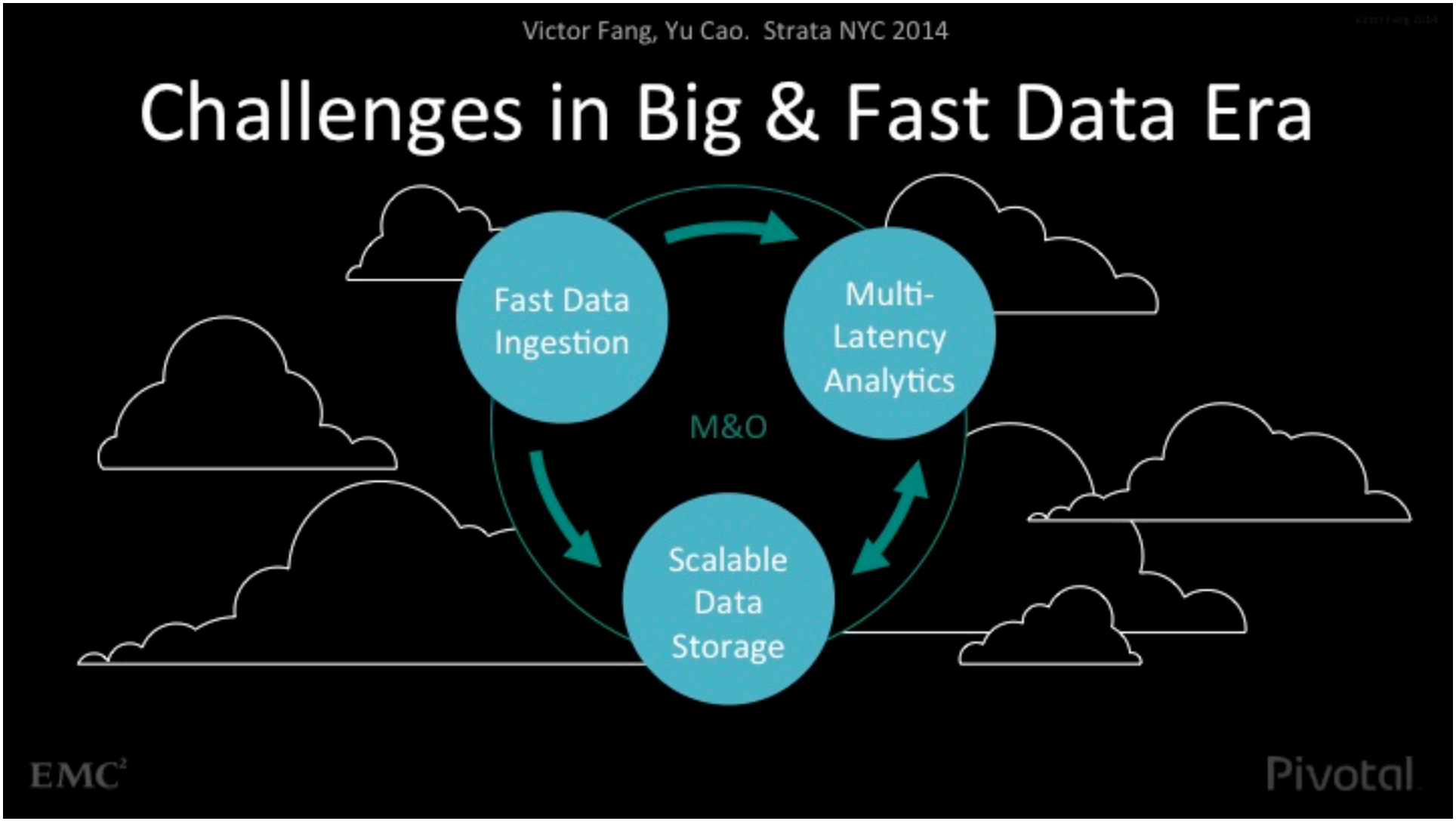
More on Industrial Internet

Deep Water Horizon oil spill monitoring

- BP oil spill at Mexico Gulf in 2010.
- Deep water cameras recorded the evidence.
- Could be better monitored & prevented w/ analytics.

Deep Space Exploration : new international initiative

- SKA : Square Kilometre Array in 2018
- 700 TB / second
- "How big data is fueling a new age in space exploration" – VentureBeat, Oct 2014.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Challenges in Big & Fast Data Era
Fast Data Ingestion
Multi-Latency Analytics
M&O
Scalable Data Storage
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Challenges in Video Data

Video Stream Formats

- Different real time protocols: MJPEG, H264, MPEG, RTSP, Proprietary, etc.
- Various bit rates consist of streaming packets.
- 100KB – MB/s.

Video File Formats

- Different compression standards: H264, MPEG, Proprietary, etc.
- Large volume files.
- GB - TB

Status Quo

Program Director, National Science Foundation, May 2014:

"(In Video Analytics,) *People are working hard, but we are not really there yet.*

Although the current applications have proven useful, today's technology has significant limitations.

Government, academic and industry researchers confront a number of challenges that range from exploring ways to more efficiently comb through huge stores of video -- essentially a ***big-data problem*** *…*

Furthermore, developments in software have ***failed to keep pace with the explosion in video camera hardware****."*

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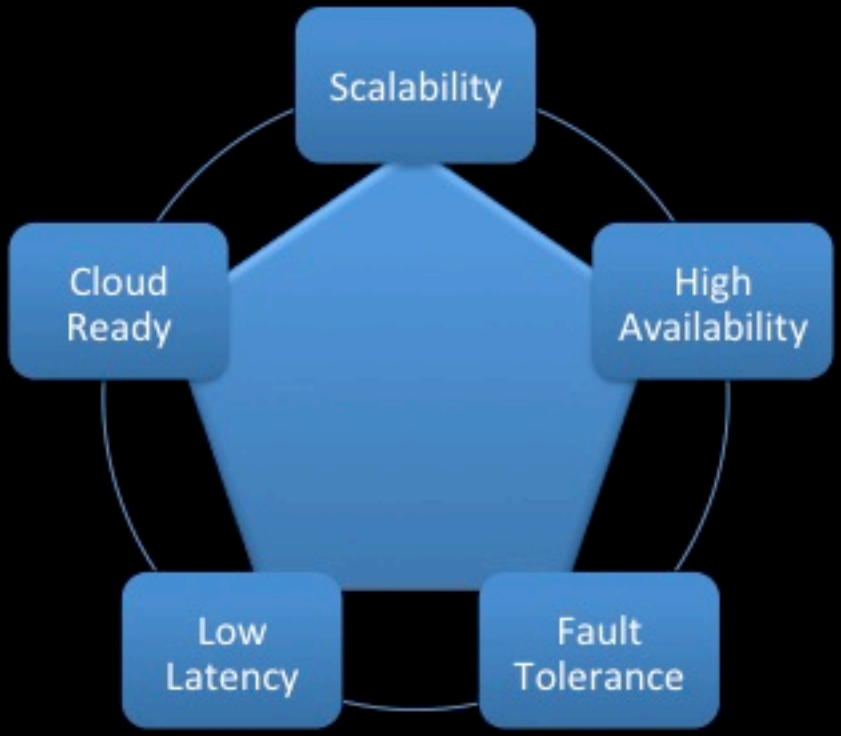
Desired Platform Features



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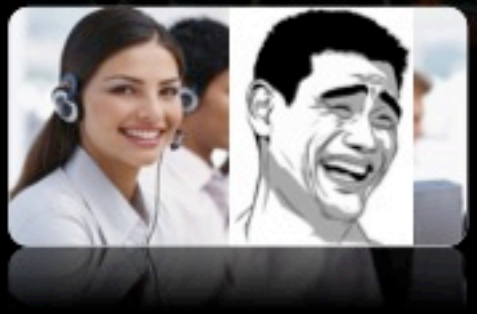
What it could look like...

+

= PROBLEM SOLVED!



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Introducing

Video Analytics Data Lake

Disruptive Technology for Video Analytics Platform

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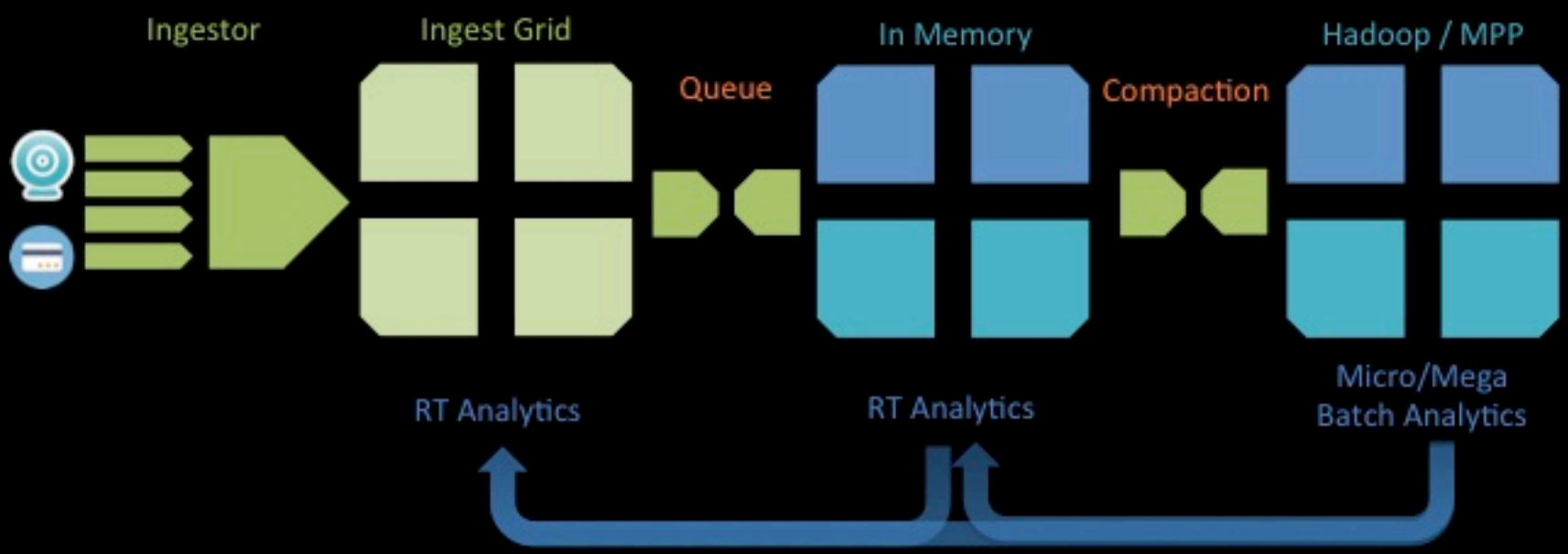
VADL Conceptual Architecture



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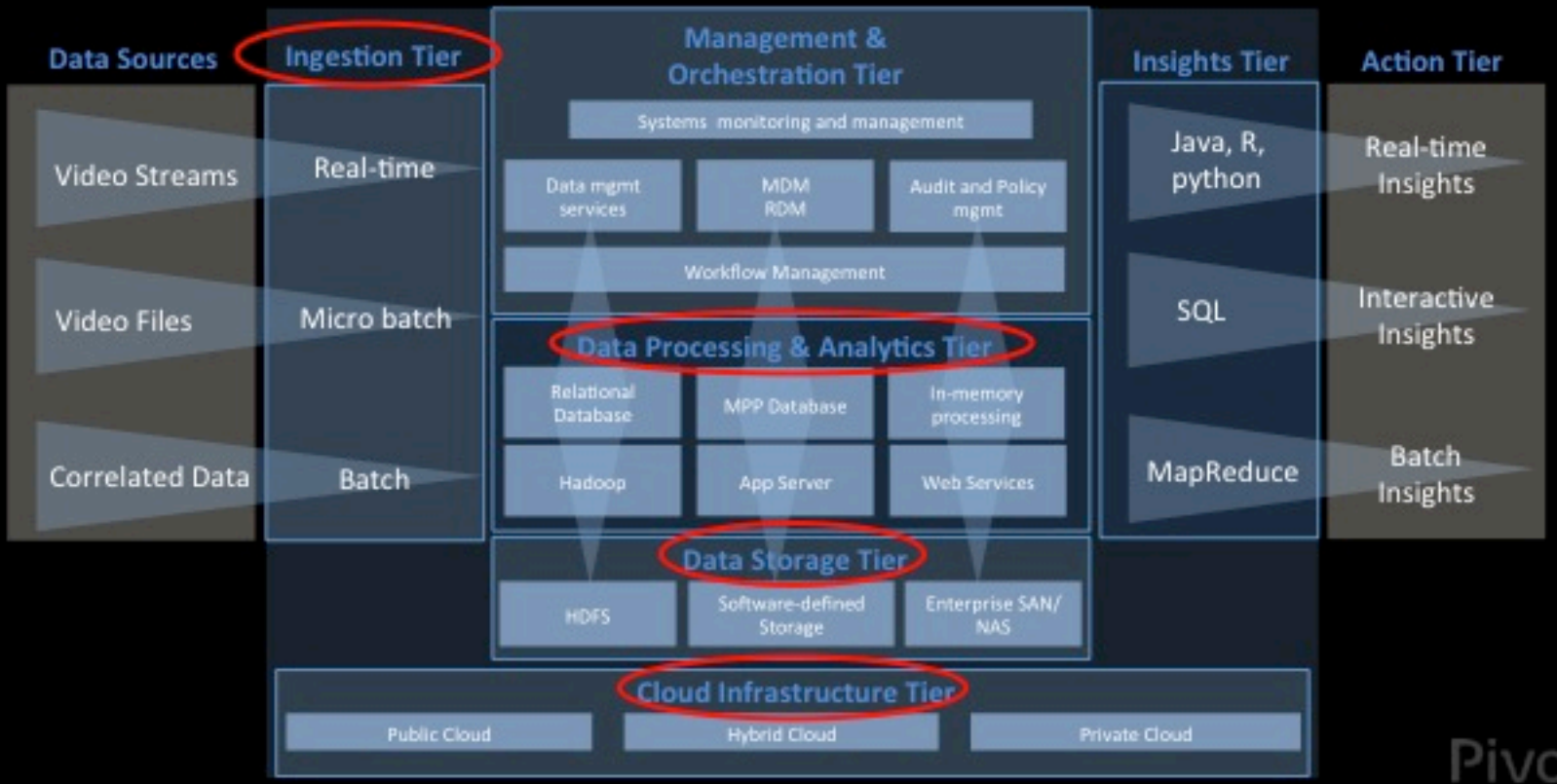
VADL Building Blocks



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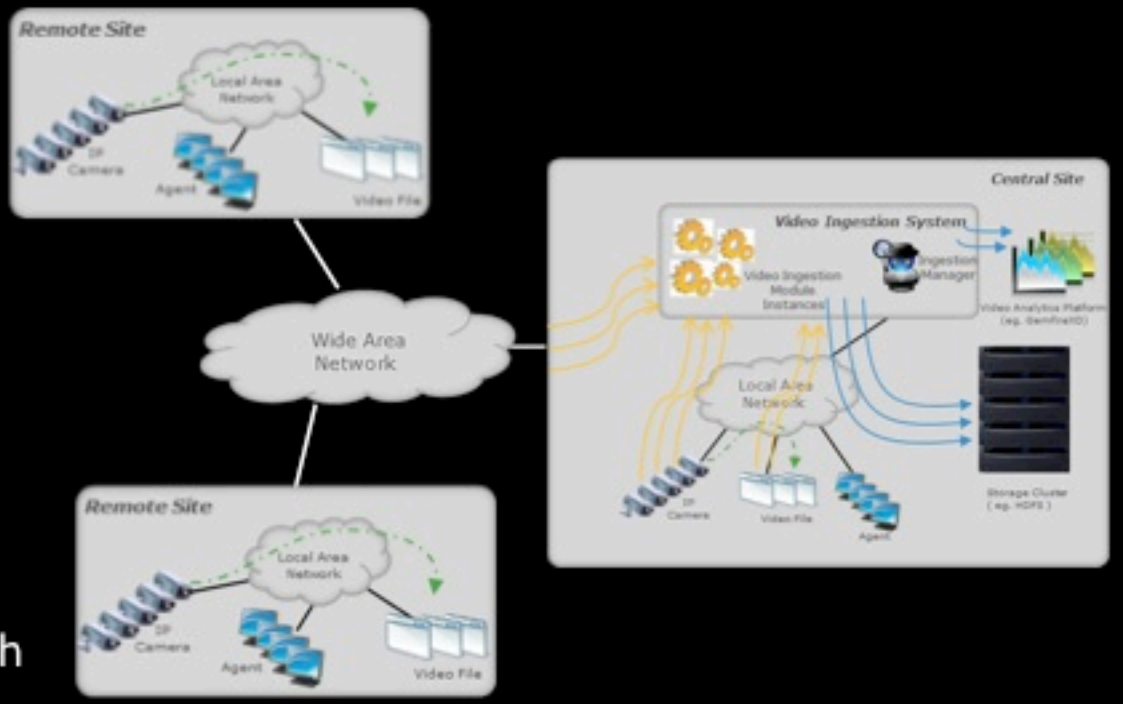
Video Data Ingestion

- Video Stream
  - From campus camera
  - Ingested into data storage
  - Pipelined to real-time analytics
- Video File
  - From remote site
  - Ingested into data storage
  - For batched analytics
- 3rd-Party Data
  - For correlated analytics with video data



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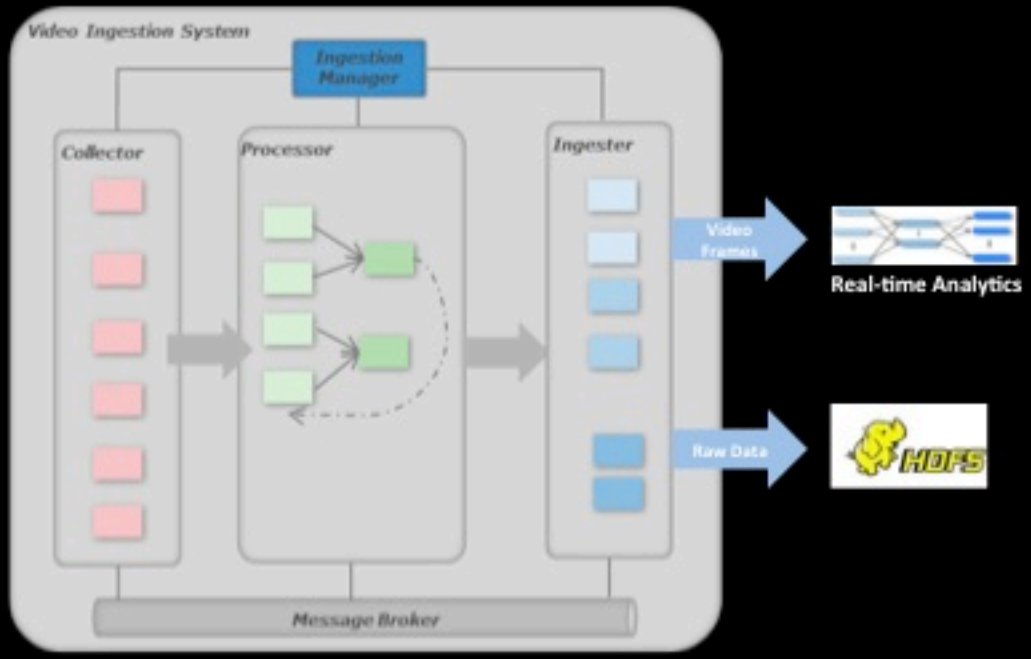
Ingestion System Design



- Ingestion Modules
  - Collector
  - Processor
  - Ingestor
- Message Broker
  - Data communication between modules via messaging middleware (e.g. RabbitMQ)
- Ingestion Manager
  - Topology management
  - Module registration
  - Job Launching
  - HA, load balancing, fault tolerance, etc

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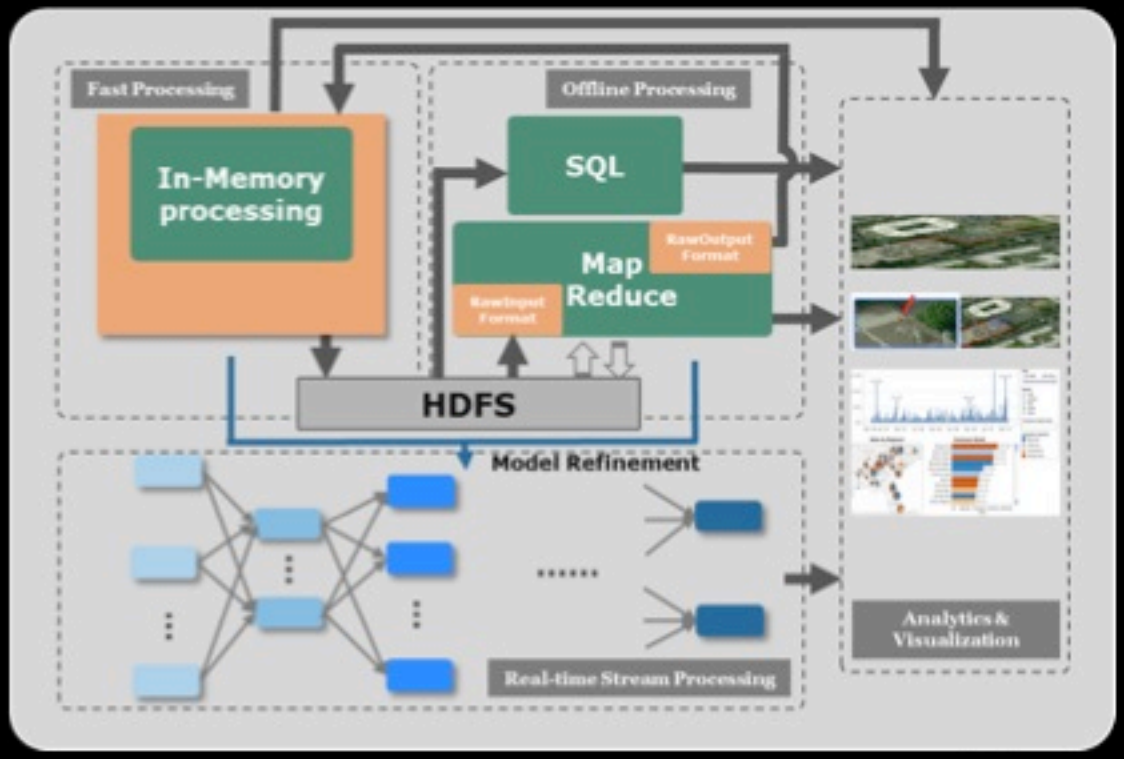
Multi-Latency Video Analytics

- Real-Time Stream Processing
  - Sub-second
  - In memory
- Fast Processing
  - Seconds to minutes
  - In memory
- Offline Processing
  - Minutes to hours
  - Persistent data storage
- Analytics Visualization
  - Actionable insights



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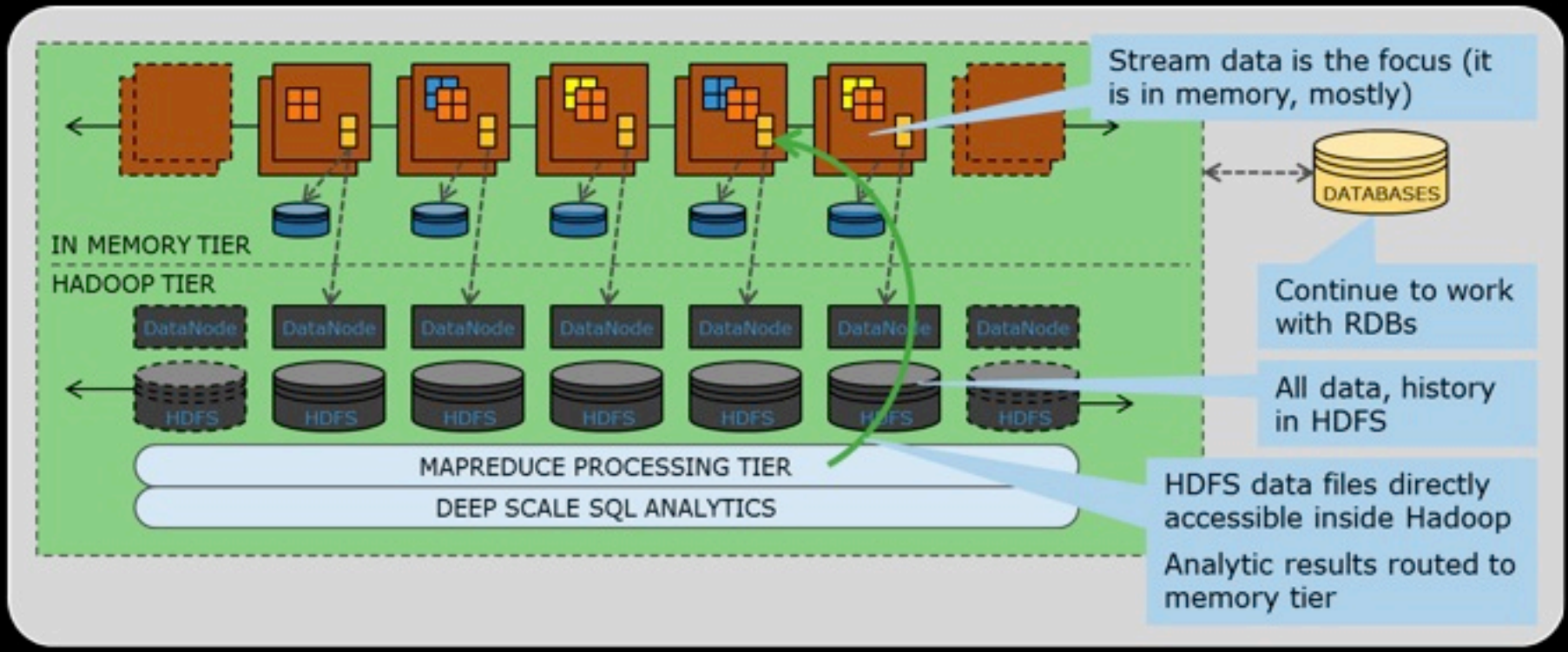
Scalable Data Storage



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Up in the Cloud

- Provision and auto-scale the computing clusters with IaaS like VMware or OpenStack
- Leverage cloud storage to share or archive non-critical data
- Deploy VCA apps at PaaS like Cloud Foundry to enable Internet and mobile access
- VCA-as-a-Service

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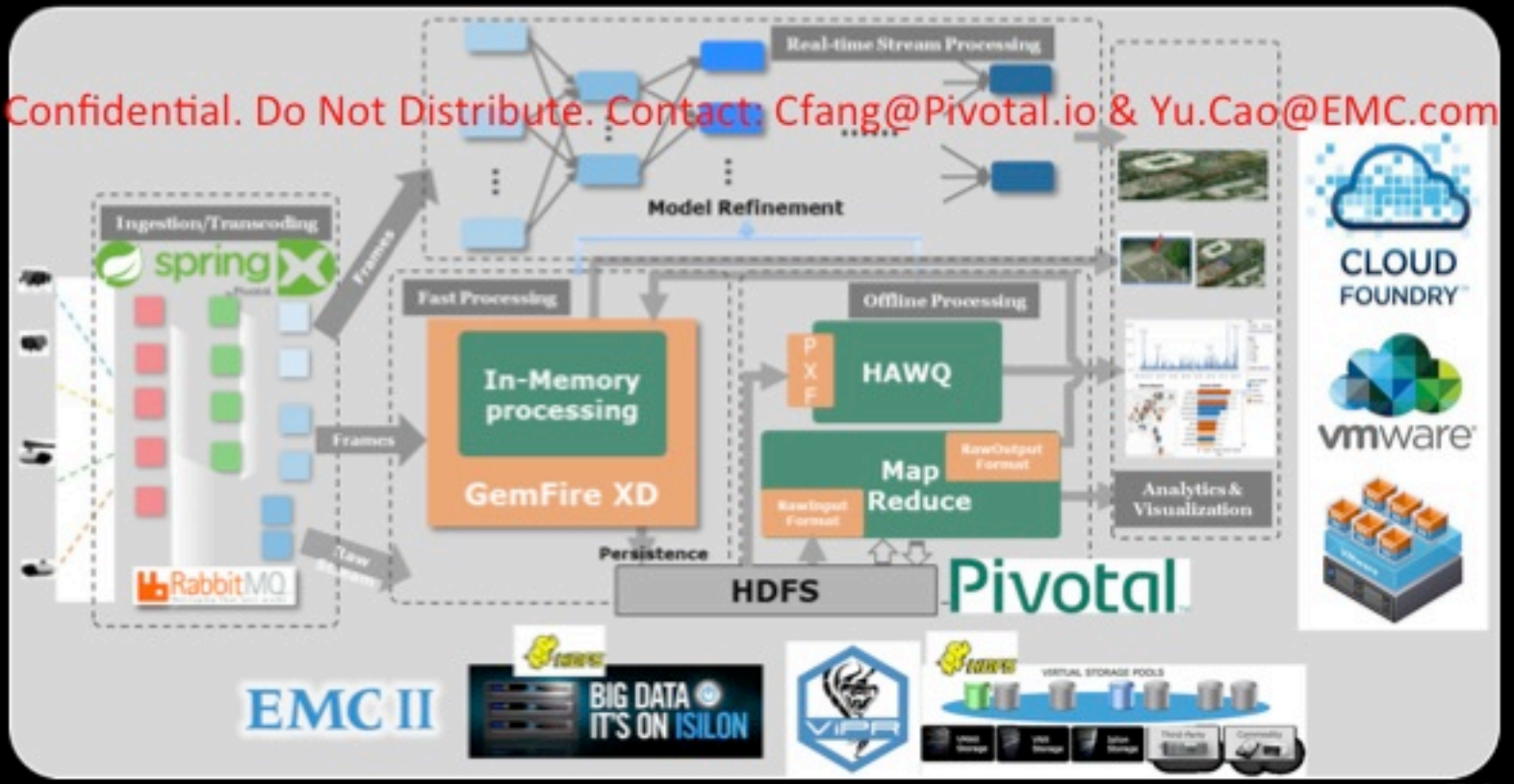
An EVP-Powered VADL Solution



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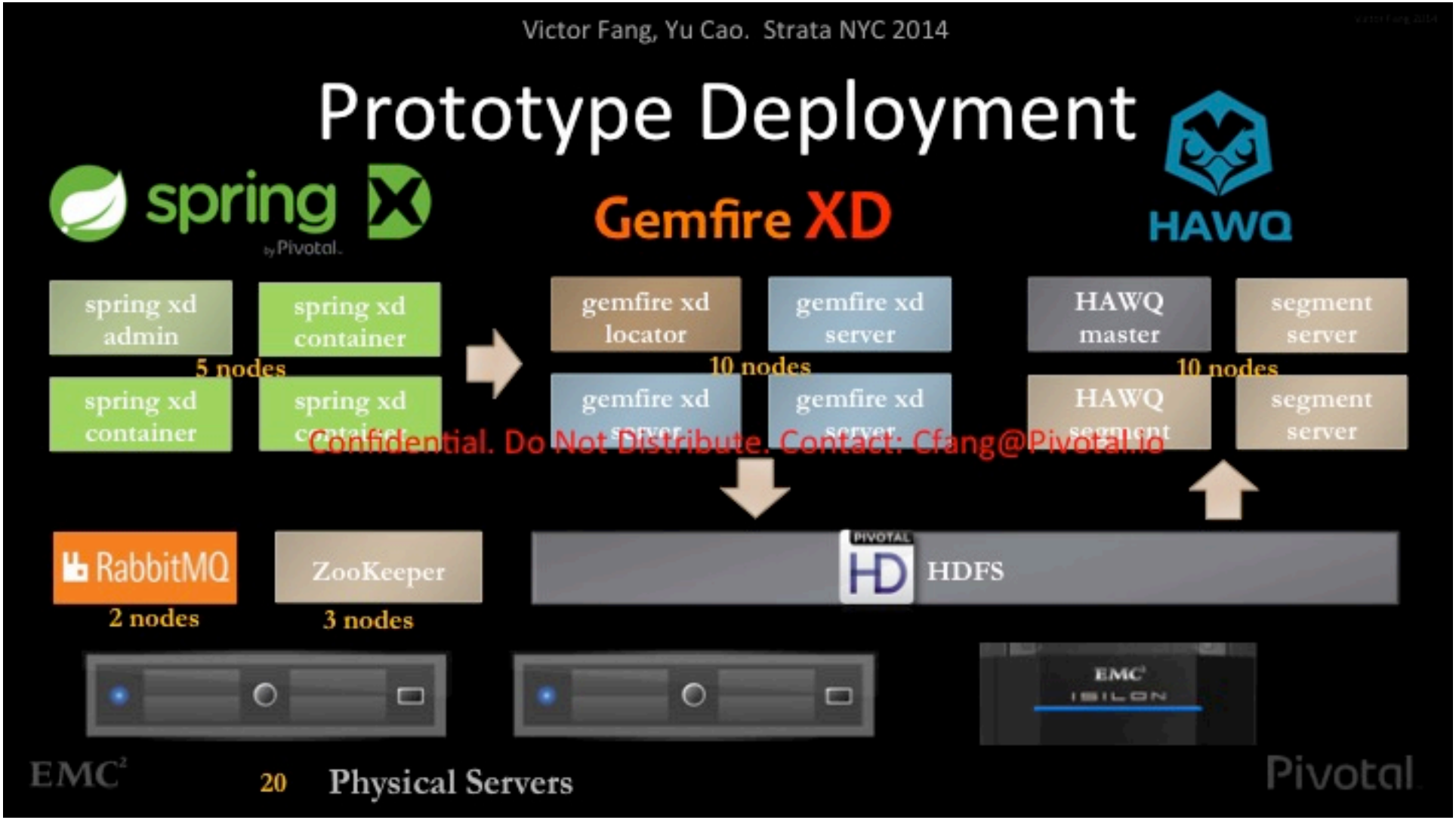
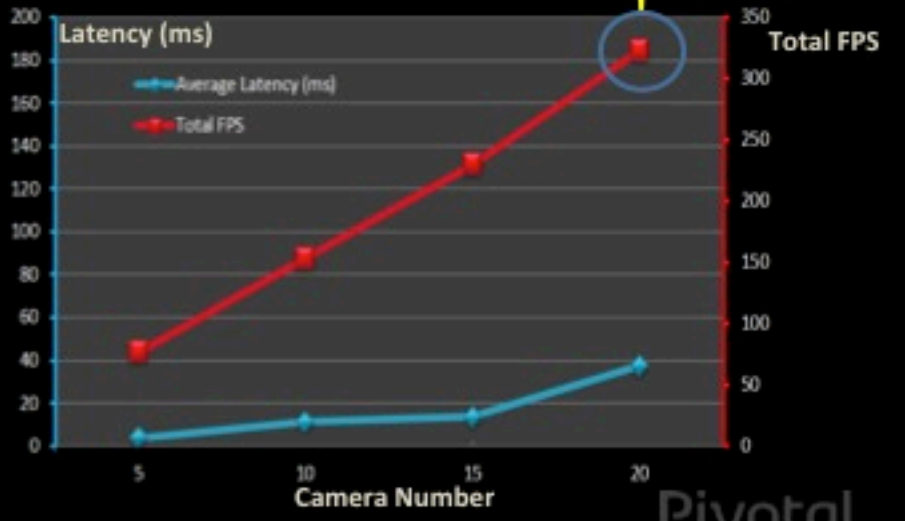
Prototype Deployment



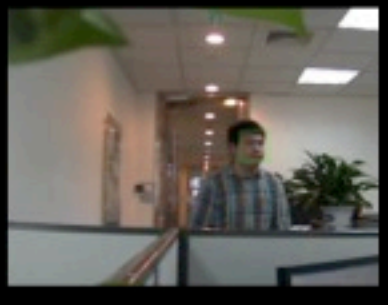
Performance Benchmark Test

- Increment the number of ingested camera streams, until the server stresses out:
  - Average FPS of each camera is about 15, frame size 640*480
  - Server hardware:
    - 8 * 4-core 2.40GHz Intel(R) Xeon(R) CPU
    - 16G memory
- Each GFXD server ingests video streams from multiple cameras, up to 20
  - Low end-to-end latency (<50ms)
  - Without loss of frame
- Overall performance is linearly scalable to cluster size



Use Case: Face Detection & Traffic Monitoring

- Face Detection in real time.
- Face Tracking via motion prediction & Adaptive Online Machine Learning to lower down false positives.
- Automatically monitor traffic



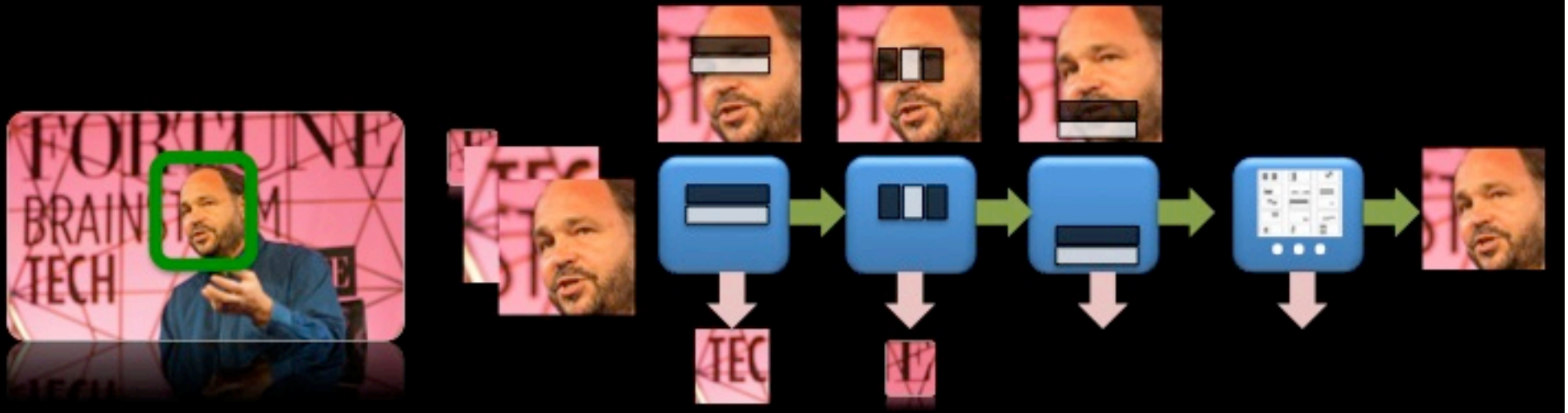
Demo Video

Demonstation:

Face Detection & Traffic Monitoring

Face Detection in Real-Time Stream

- AdaBoost $w_{t+1,i} = w_{t,i}\beta_t^{1-e_i}$, $\beta_t = \frac{e_t}{1-e_t}$ + Cascaded Trees + 160K Haar-Like features *
- Multi-stage Ensemble classifiers promptly reject 99%+ of sub-images
- Real time detection : ~150 ms / frame in Java



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* Viola, Jones: Robust Real-time Object Detection, IJCV 2001
- Photo Courtesy of Paul Maritz, CEO, Pivotal.

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Use Case: Real-time Daylight World Map

- Real-time Streaming **15** live video feeds distributed worldwide.
- **Dominant color extraction** for each video: 50ms/frame.
- Real-time Daylight World Map Visualization App on Cloud Foundry.
- Next will demo the results for videos taken in 24 hours.

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Video demo

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For Data Scientists…

Technology Enablement for Data Science

- Batch processing
  - Off line training : MapReduce …
- Sequential processing
  - Online machine learning : SpringXD, GemfireXD …
  - Object Tracking, Online anomaly detection, etc.

Towards the Digital Brain & Beyond

VADL is another attempt towards Digital Brain

- Kaushik Das, "*Data Science and Smart Systems: Creating the Digital Brain*", Strata, Feb 2014, Santa Clara.

Data Science inspired by Brain Science :

- **This is just the beginning**
- *Incognito* : What is in a conscious mind?
- *On Intelligence*: Human brains are constantly doing Prediction & Anomaly Detection.

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Q/A?

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