Embedded Networks Laboratory

MobiSys'11

Odessa: Enabling Interactive Perception Applications on Mobile Devices

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Emerging Mobile Perception Applications

Sensing
- GPS
- Accelerometer

Computation
- Dual-Core CPU

Communication
- Cloud Infrastructure

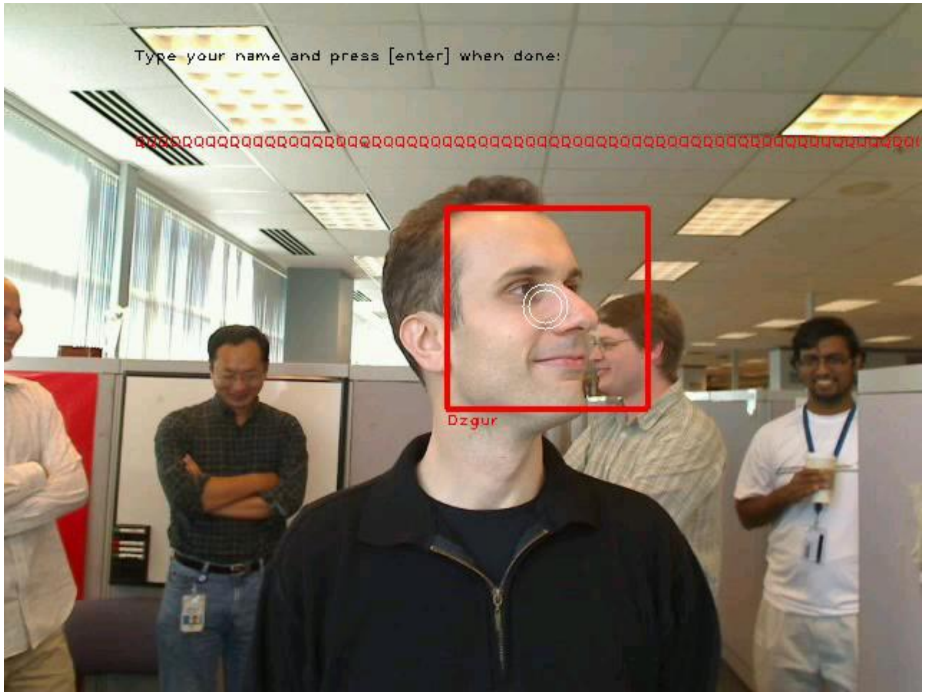
Sensing Applications
- Activity Recognition
- Health, Traffic Monitoring
- Location-Based Service
- Participatory Sensing

Vision-based Interactive Mobile Perception Applications

Face Recognition

Object and Pose Recognition

Gesture Recognition



Common Characteristics

Interactive

- Crisp response time (10 ms ~ 200 ms)

High Data-Rate

- Processing video data of 30 fps

Compute Intensive

- Computer Vision based algorithms

Enabling Mobile Interactive Perception

Performance

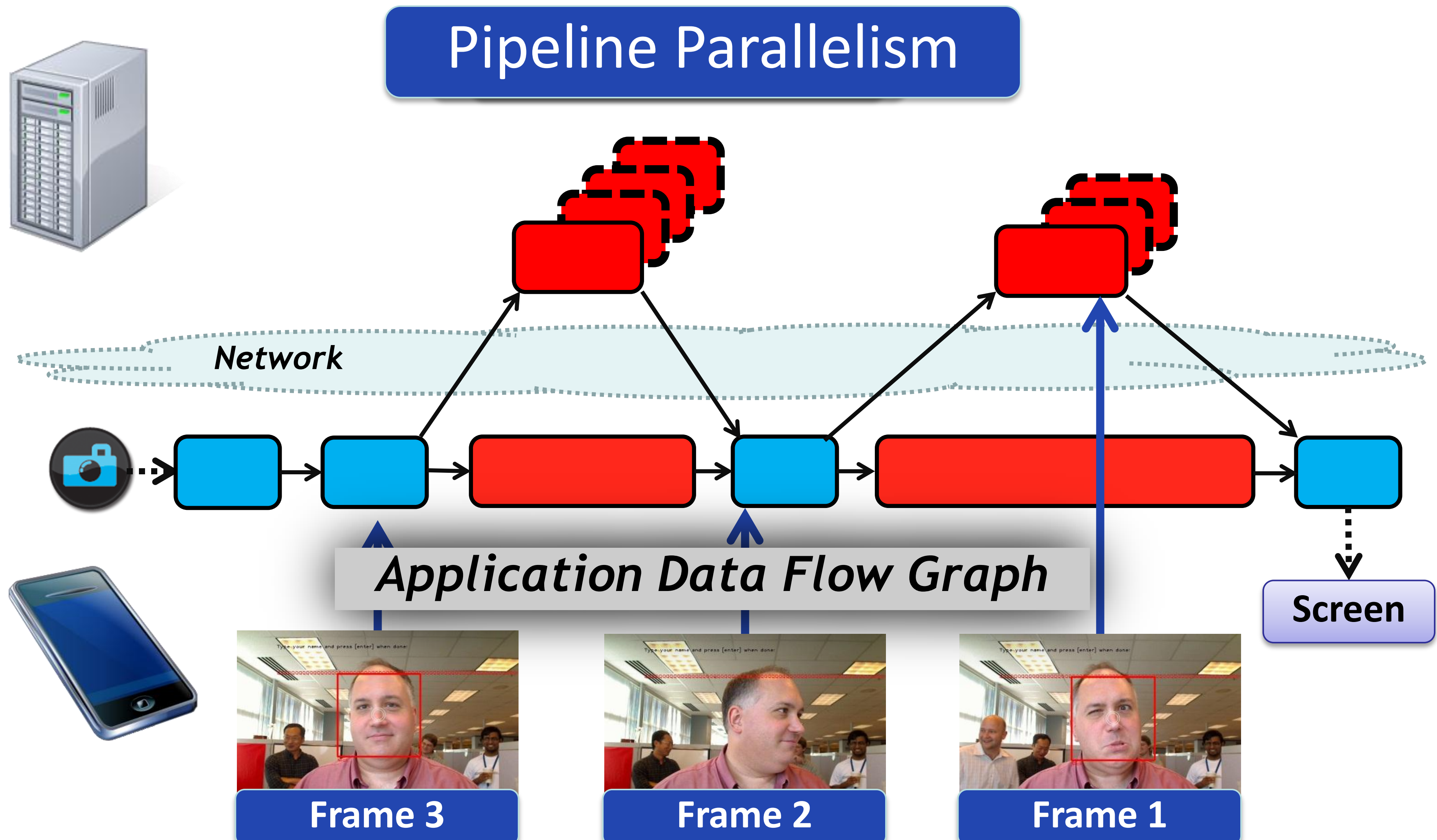
Throughput ↑ **Makespan** ↓

Application	Throughput	Makespan
Face Recognition	2.50 fps	2.09 s
Object and Pose Recognition	0.09 fps	15.8 s
Gesture Recognition	0.42 fps	2.54 s

All running locally on mobile device

Video of 1 fps

Two Speed-up Techniques



Main Focus

Data Flow Structure

Offloading + Parallelism

System Support

Enable Mobile Interactive Perception Application

Contributions

What factors impact offloading and parallelism?

Measurement

How do we improve throughput and makespan simultaneously?

Odessa Design

How much benefits can we get?

Evaluation

Measurement

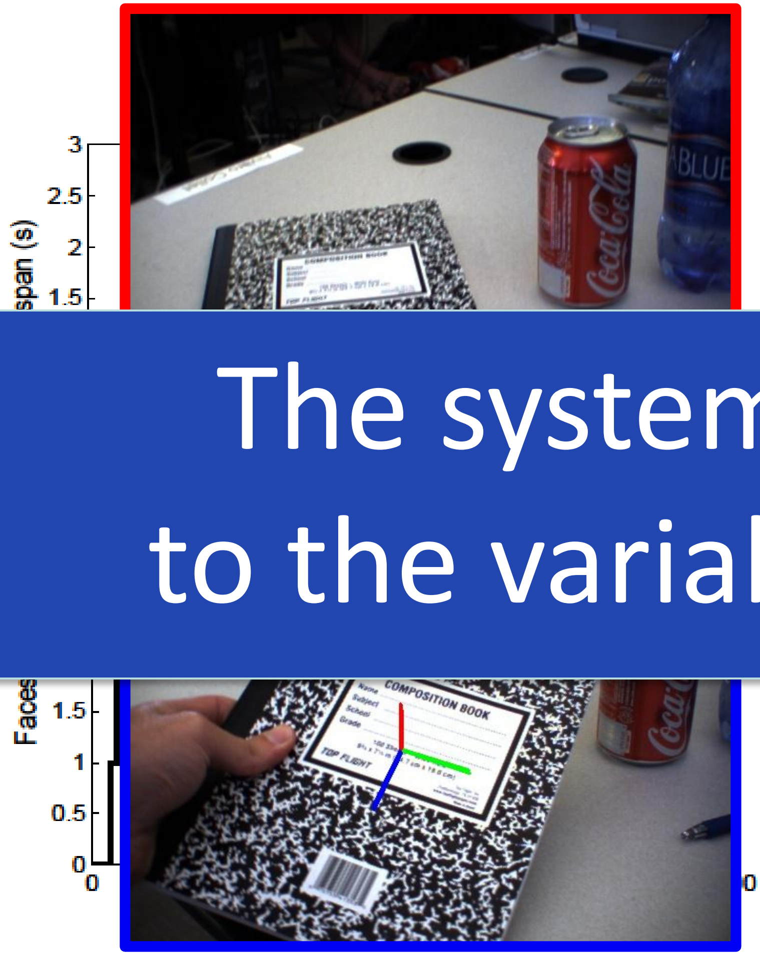
Input Data Variability

Varying Capabilities of Mobile Platform

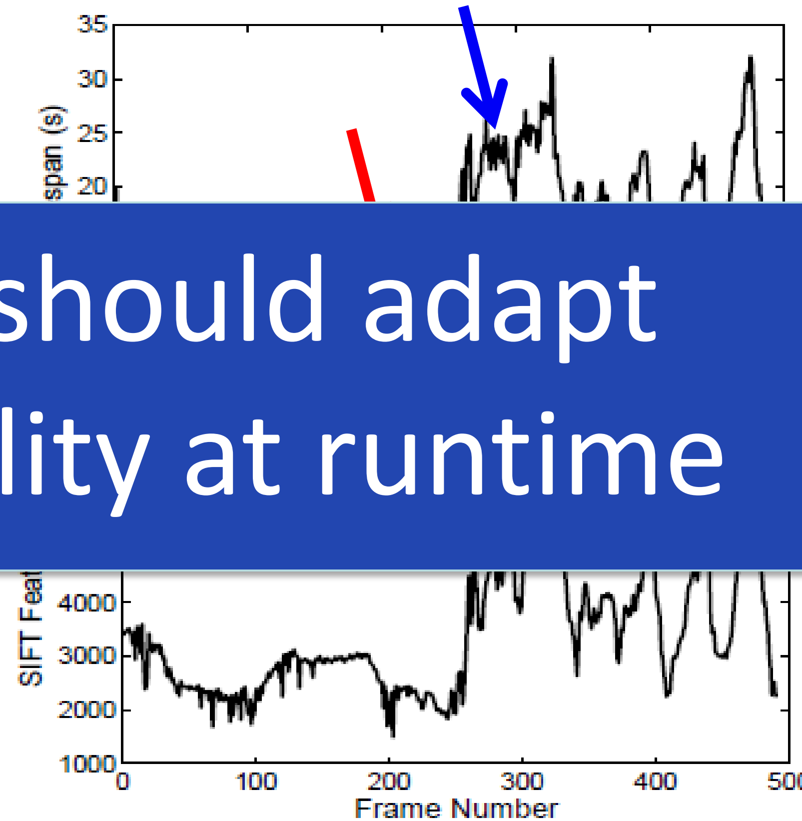
Network Performance

Effects of Parallelism

Lesson I : Input Variability



Object and Pose Recognition



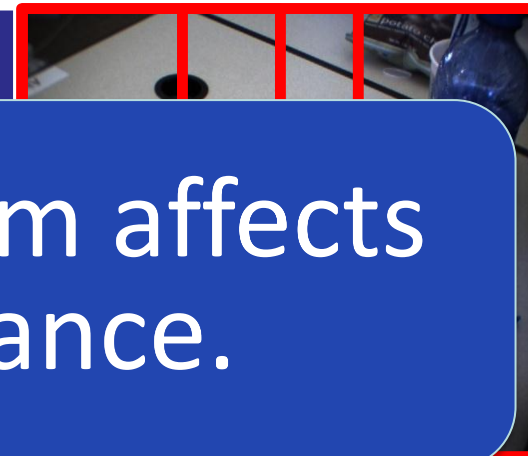
The system should adapt to the variability at runtime

Impact of input variability

Lesson II: Effects of Data Parallelism

Object and Pose Recognition

# of Threads	Thread 1	Thread 2	Thread 3



The level of data parallelism affects accuracy and performance.

Input Complexity

Segmentation Method

Summary: Major Lessons

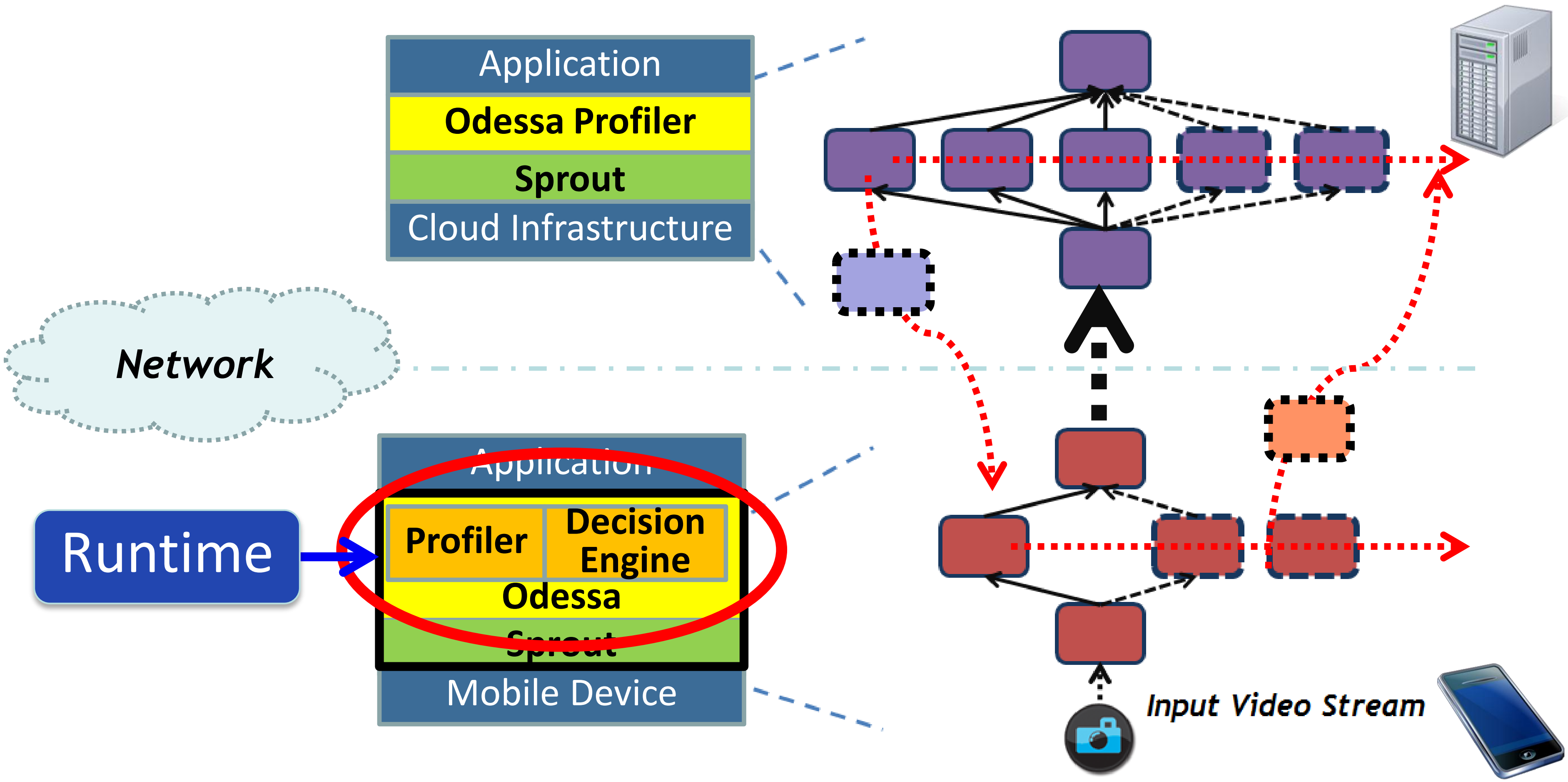
Offloading decisions must be made in an adaptive way.

The level of data parallelism cannot be determined a priori.

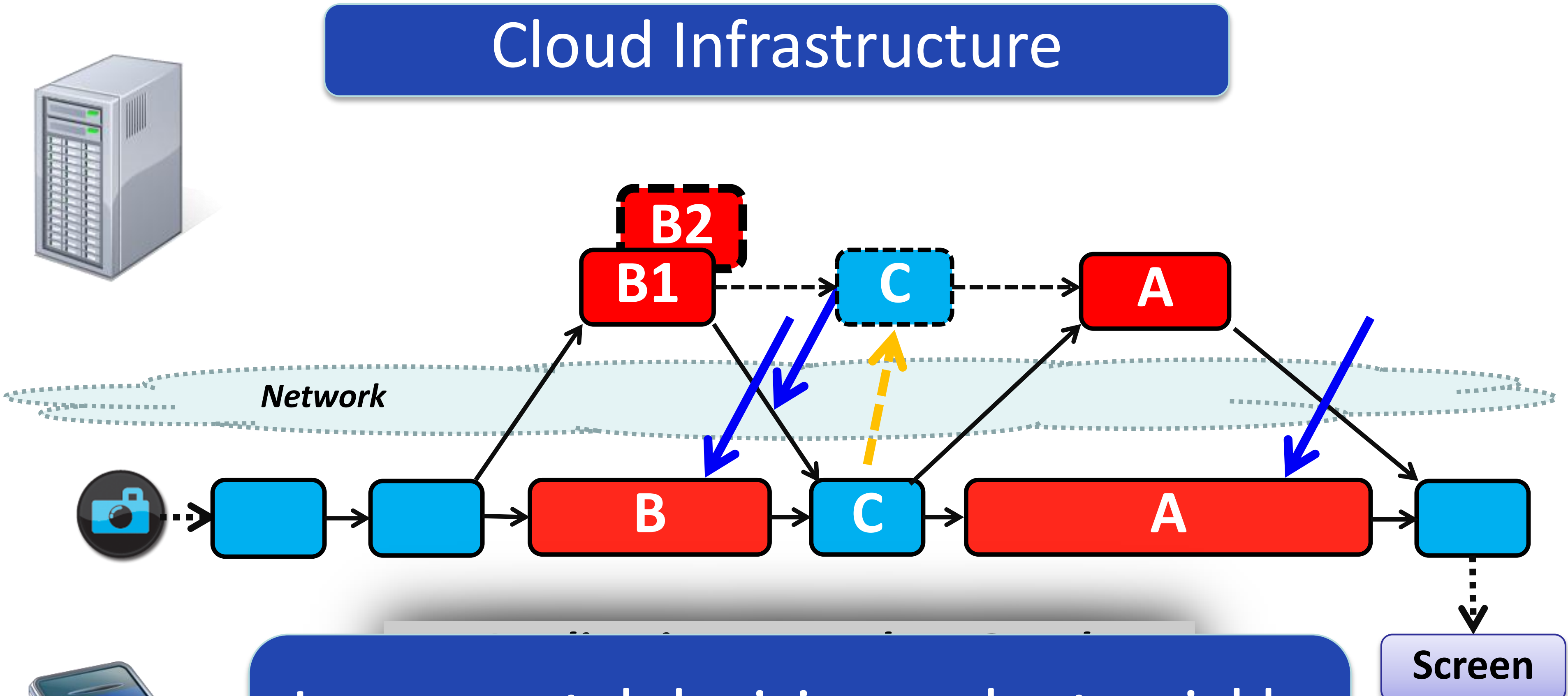
A static choice of pipeline parallelism can cause sub-optimal performance.

Odessa

Offloading **DE**cision **S**ystem for **S**treaming **A**pplications

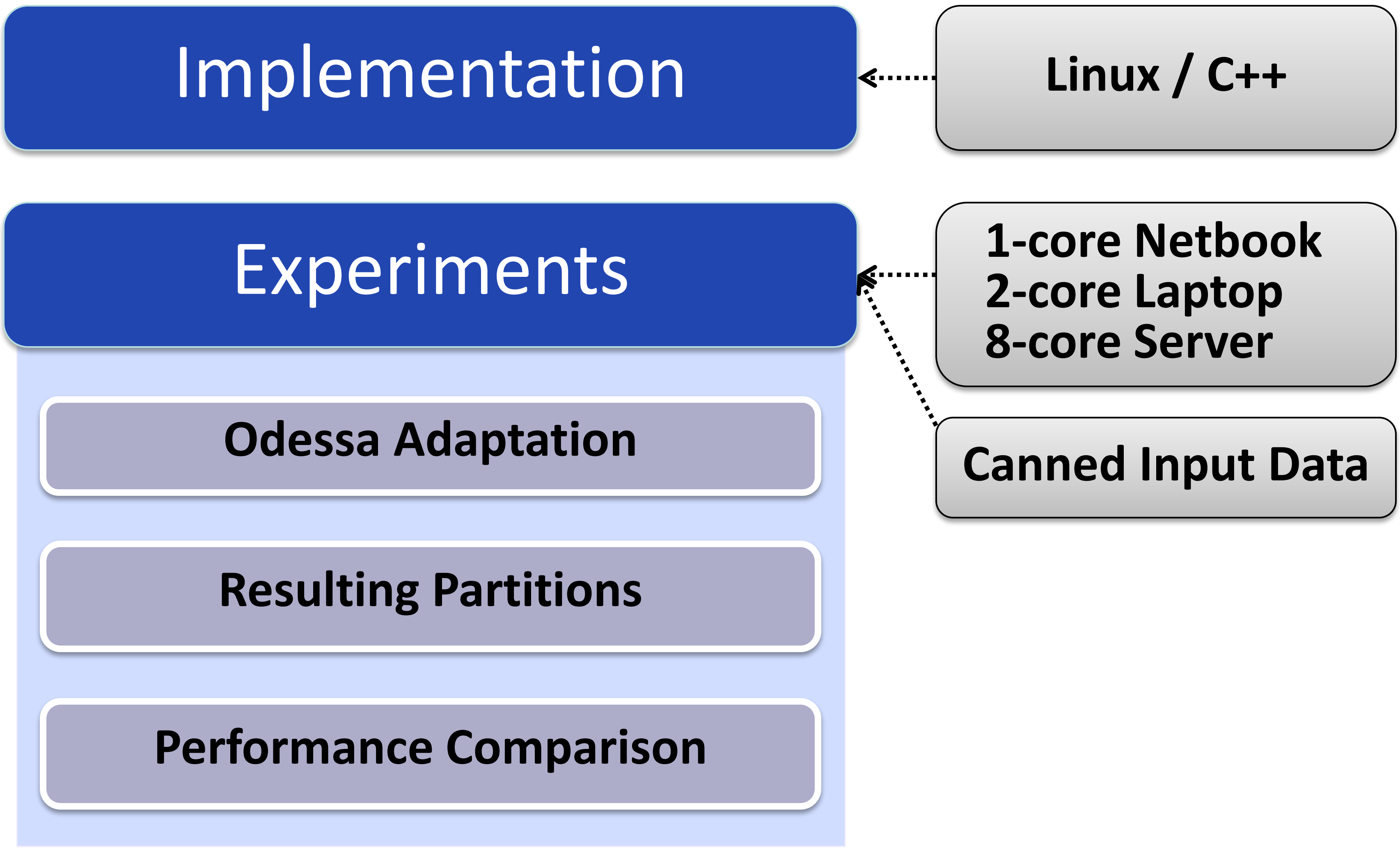


Incremental Decision Making Process

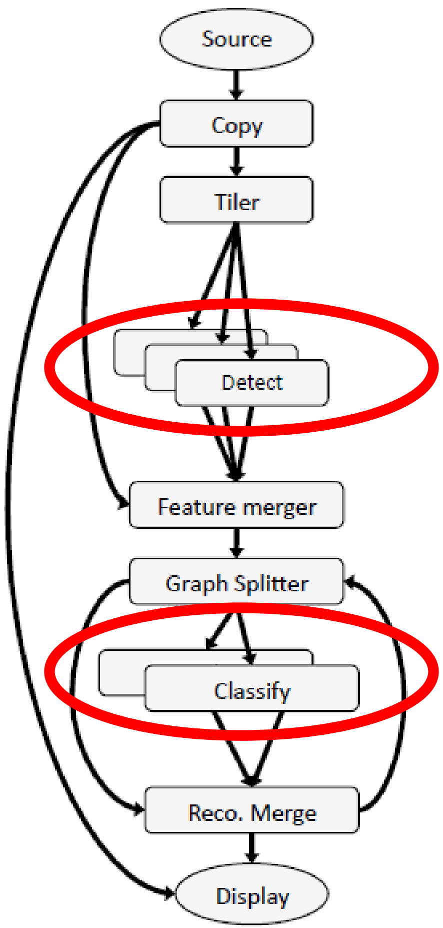


Incremental decisions adapt quickly to input and platform variability.

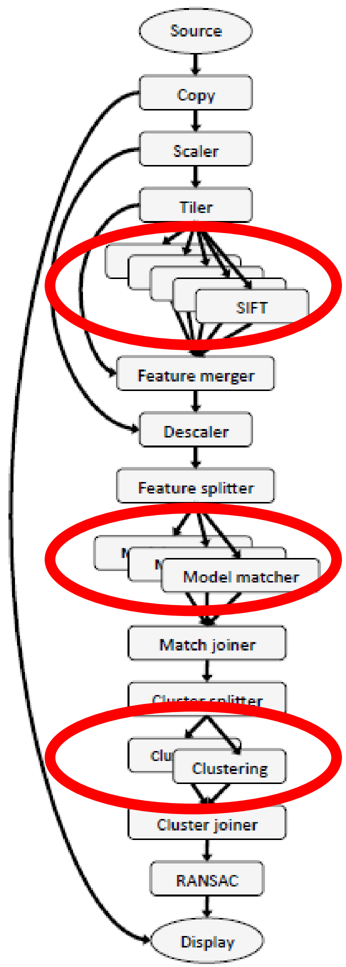
Evaluation Methodology



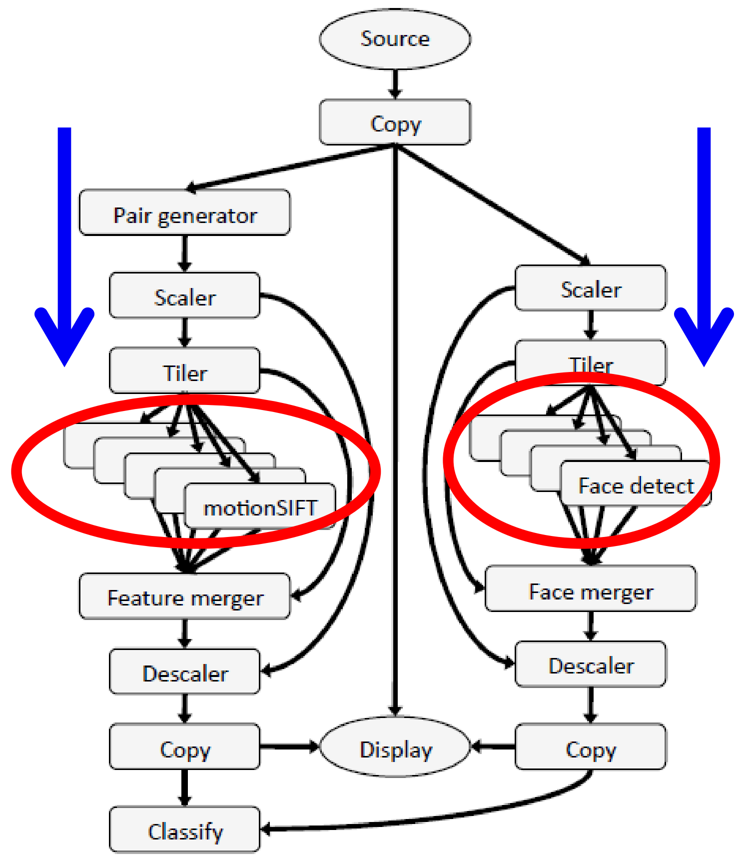
Data-Flow Graph



Face Recognition



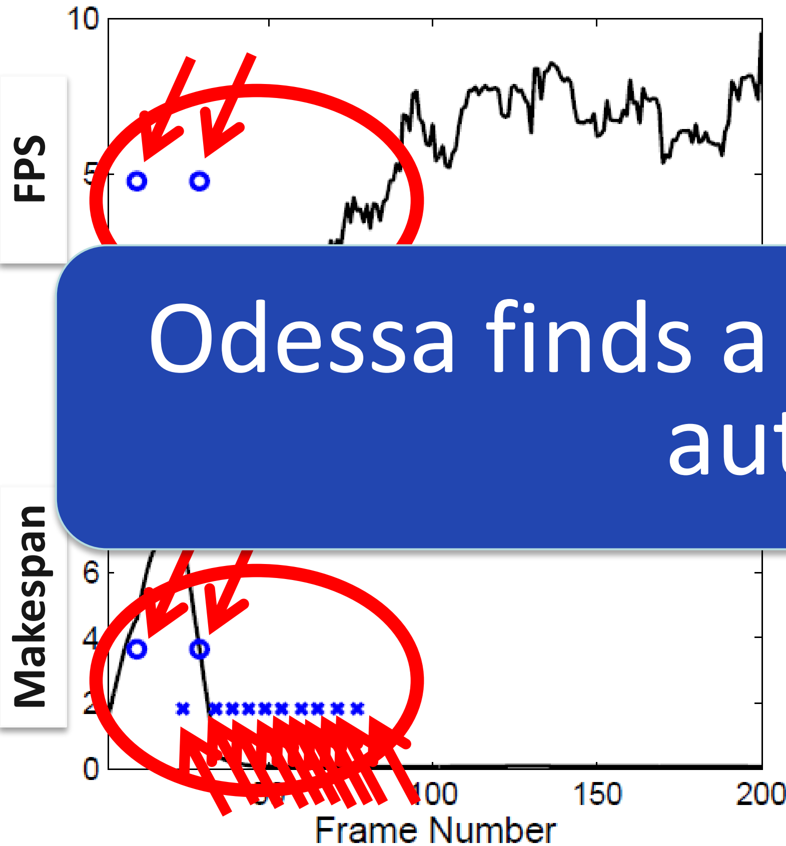
Object Pose Estimation



Gesture Recognition

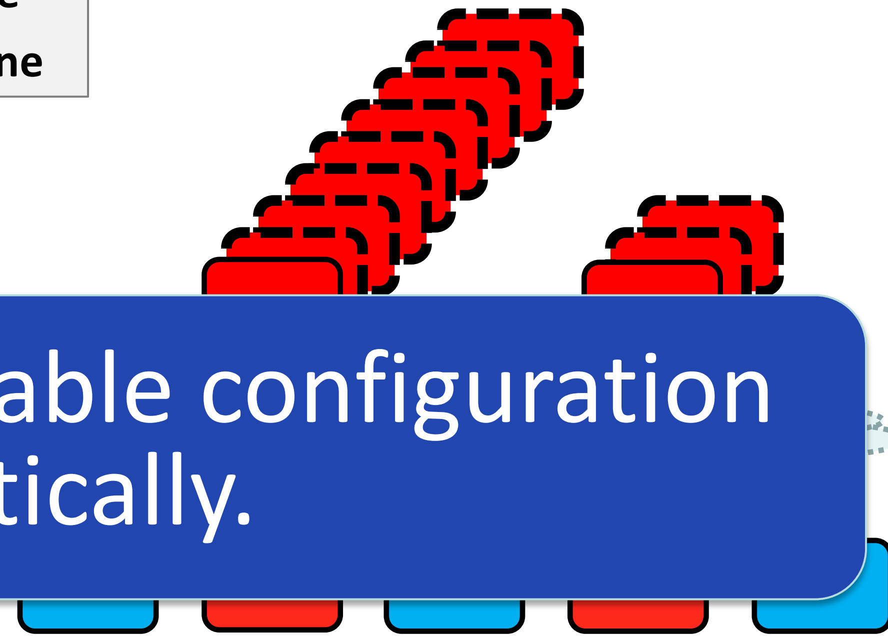
Odessa Adaptation

Object and Pose Recognition



Mobile Device

8-core Machine



1-core

Odessa finds a desirable configuration automatically.

Resulting Partitions in Different Devices

Face Recognition

Client Device	Stage Offloaded and Instances	Degree of Pipeline Parallelism
Mobile Device	Face detection (2)	3.39

Resulting partitions are often very different for different client devices.

Client Device	Stage Offloaded and Instances	Degree of Pipeline Parallelism
Mobile Device	Face Detection (1) Motion-SIFT Feature (4)	3.06
Dual Core Notebook	Face Detection (1) Motion-SIFT Feature (9)	5.14

Performance Comparison with Other Strategy

Object and Pose Recognition Application

Strategy	Throughput (FPS)	Makespan (Latency)
Offline-Optimal	6.49	430 ms
Odessa	**6.27**	**807 ms**

Odessa performs 4x better than the partition suggested by domain expert, close to the offline optimal strategy.

Mobile Device

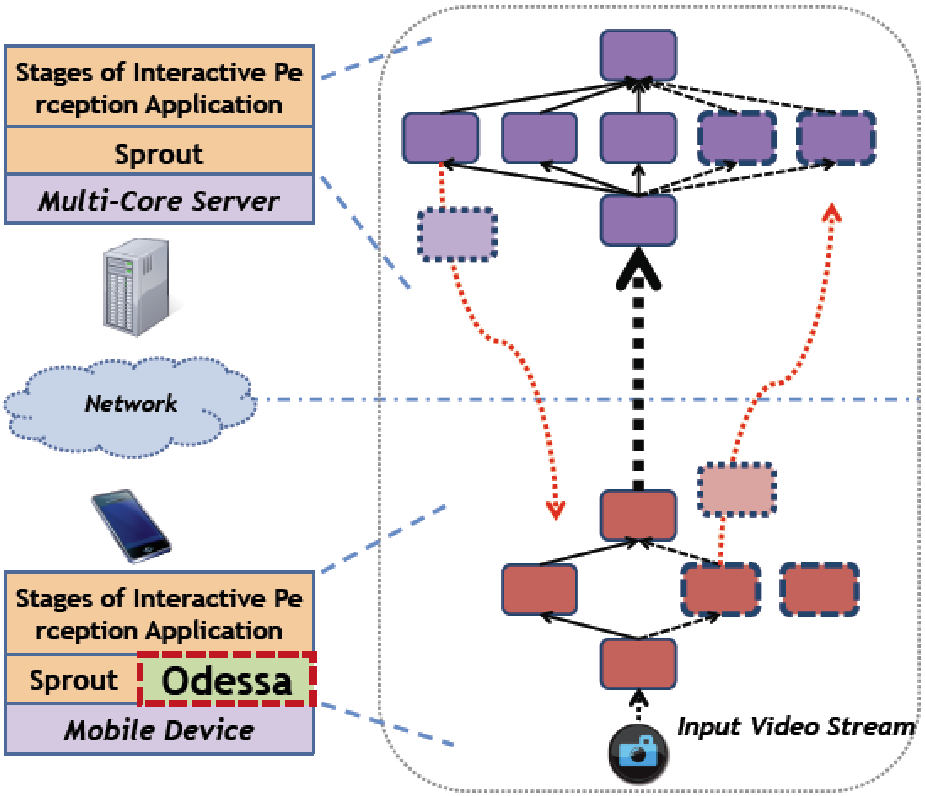
Related Work

- ***ILP solver*** for saving energy: [MAUI] [CloneCloud]
- ***Graph-based*** partitioning: [Gu'04] [Li'02] [Pillai'09] [Coign]
- ***Static Partitioning***: [Wishbone] [Coign]
- A set of ***pre-specified*** partitions: [CloneCloud] [Chroma] [Spectra]

Objectives | Variability | Migration, Contention | Parallelization

→ **Odessa**

Summary of Odessa



Adaptive & Incremental runtime for mobile perception applications

- Odessa system design using novel workloads.
- Understanding of the factors which contribute to the offloading and par allelism decisions.
- Extensive evaluation on prototype implementation.

Thank you

“Any questions?”