Device Clouds: Integrating Edge Devices to Deliver End User Services

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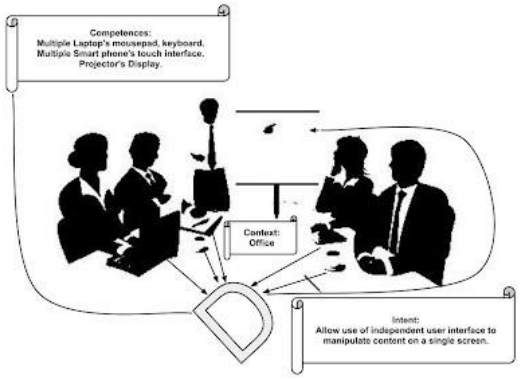
Introduction

- Devices, devices, everywhere…
  - Internet of Things panel yesterday
  - 10s of B and counting
- Not just generating data, also computational capabilities…
- Goal -> enable realization of rich dynamic services utilizing remote clouds, local and nearby capabilities

Motivating Examples: Dynamic End User Services

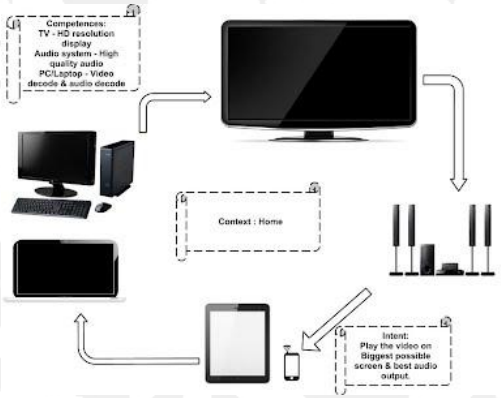
Diverse devices; variable accessibility of nearby and remote cloud resources; dynamic changes in end user interests

office/retail



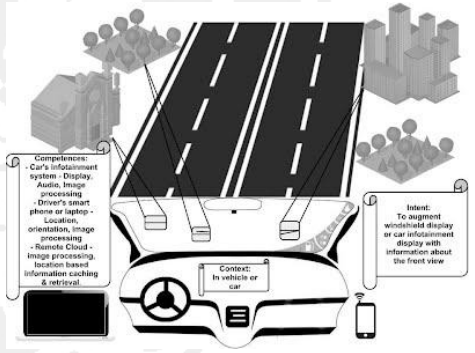
Multiple smartphones control/interact with single presentation screen

home



Dynamic select screen and decoding quality based on where user is and what she is watching

automotive



Navigation system with personalized guidance, and realtime scene recognition and analysis

Motivating Examples: Dynamic End User Services

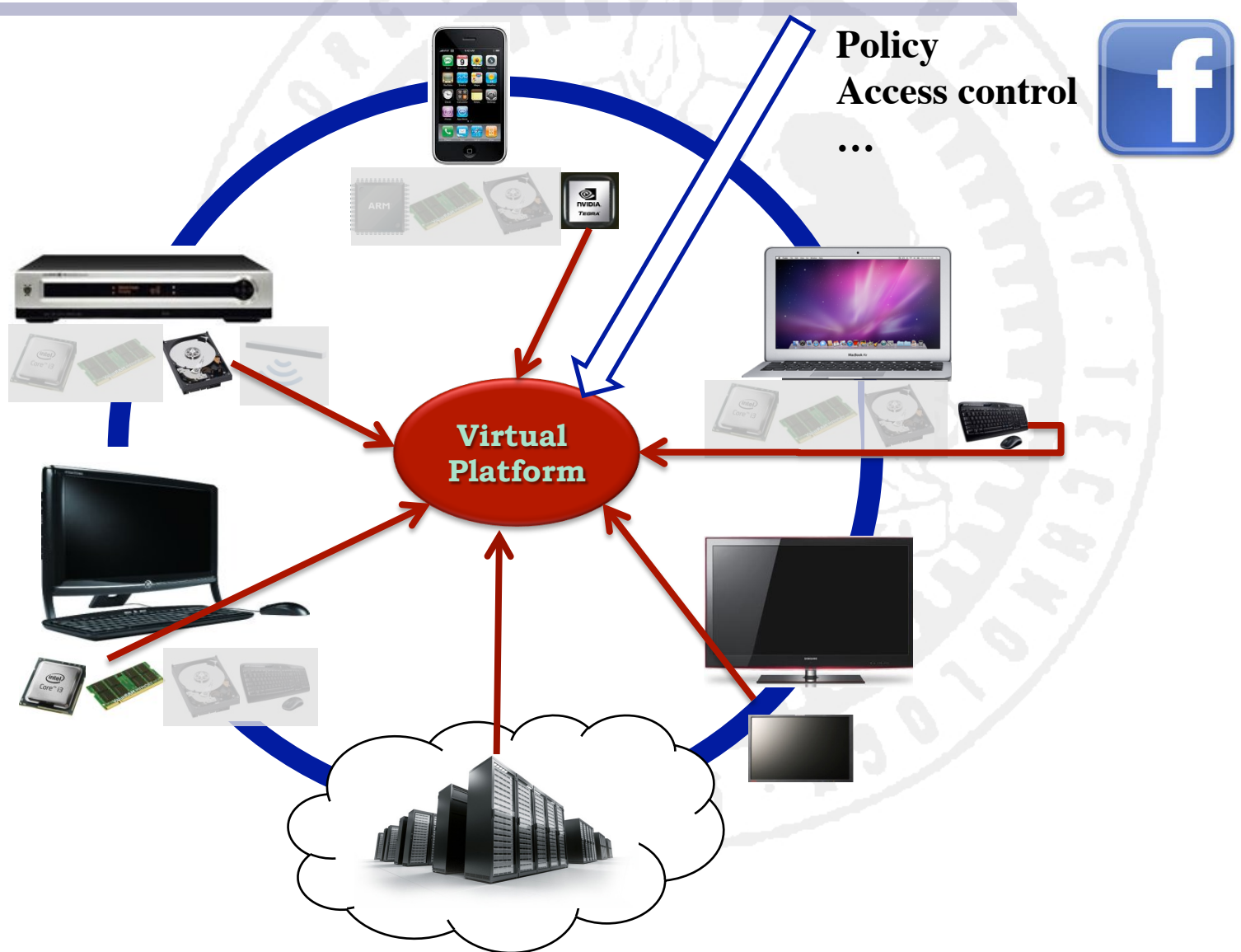
Diverse devices; variable accessibility of nearby and remote cloud resources; dynamic changes in end user interests

- Heterogeneous **C**ompetencies
- End-user-specific **I**ntent
- Dynamic **C**ontext

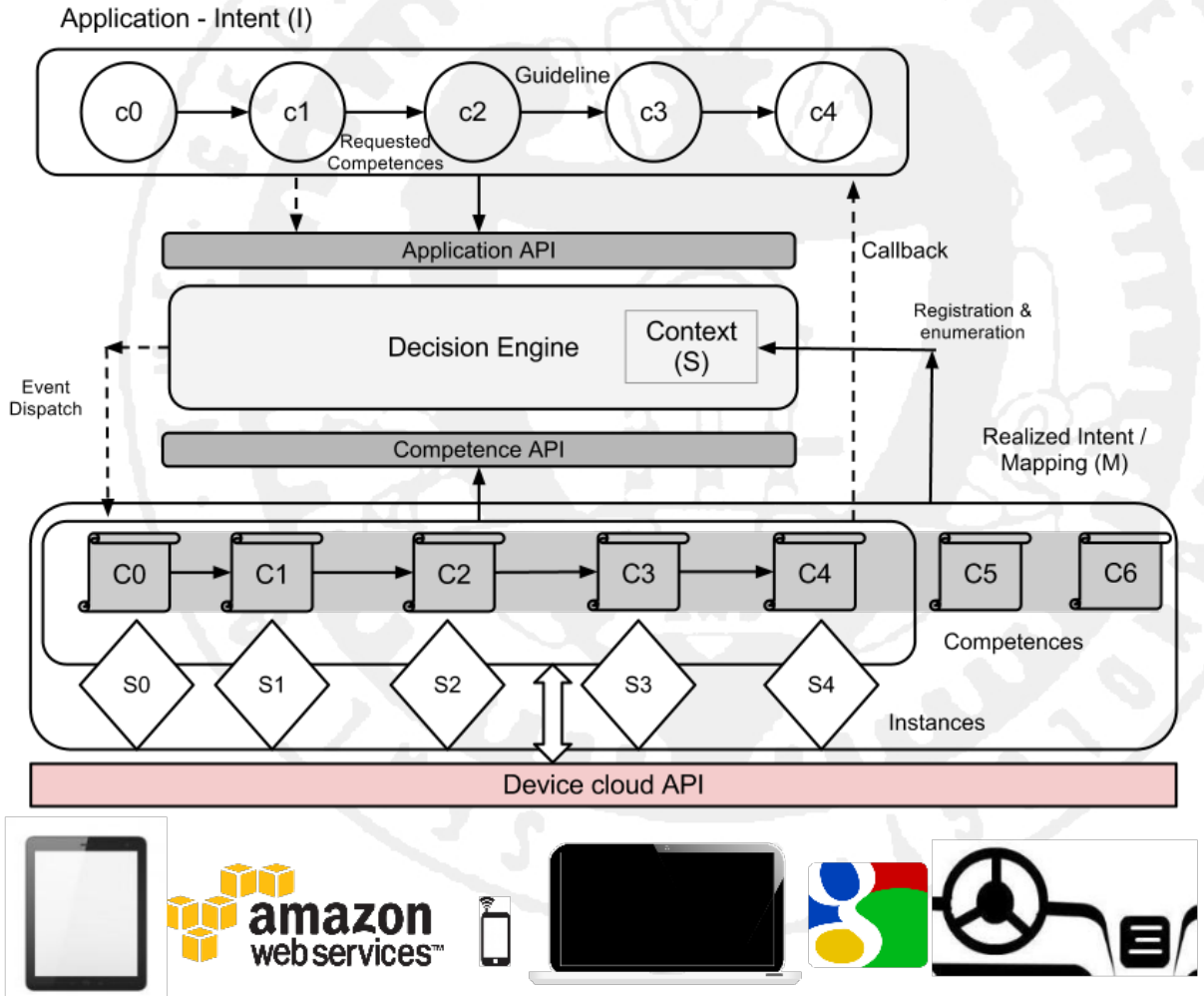
Device Cloud Approach

- **Stratus:** assembly of disparate resources – local/nearby devices and remote cloud resources as a computational platforms. (Minsung Jang)
- **CAF:** software runtime to map (and remap) end user services depending on dynamically changing CIC. (Ketan Bardhwaj)

Stratus: Virtual Platform



CAF Software Architecture



Competence

- Defined as a tuple representing a device's exposed functionality, characteristics, availability and accessibility.
  - Static part
    - Functional description
    - Associated quality parameters
    - Physical characteristics
  - Dynamic part
    - Means to utilized a competence.
    - Current state of resources.

Intent

- Represents end user's desires.

- Defined as an ordered sequence of events on '*partially specified*' competences linked by guidelines.
  - An ordered sequence of events
  - List of '***partly specified competences***'.
  - Linked by '***guidelines***'.

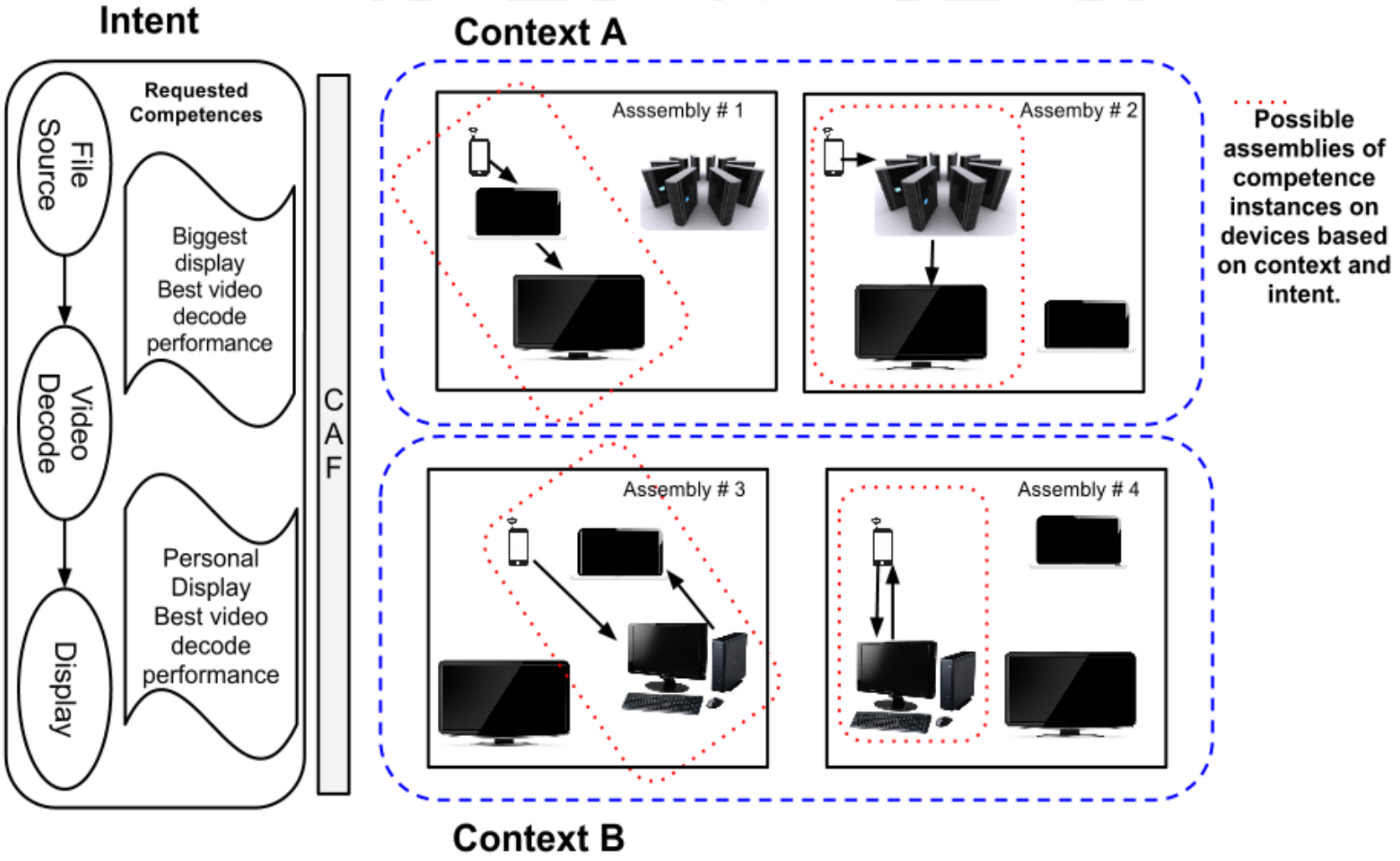
Intent - 3Ts of Guidelines

- Topology
  - Connection configuration of CAF overlay
  - CAF supported topology types
    - Linear, Branching, Many to One etc.
- Traversal
  - Event traversal
  - CAF supported types
    - Synchronous, Asynchronous, Listening etc.
- Tie (as in verb)
  - Pinning constraints

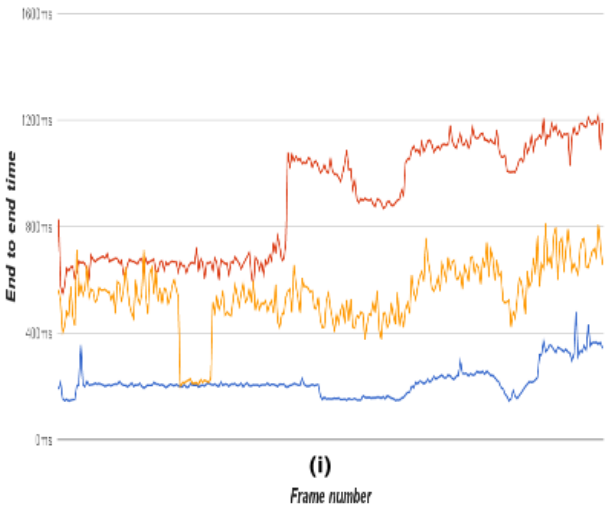
Context

- Defined as the set of currently accessible competences.
- CAF Formulation distinguishes among
  - Offered, local, remote, cached competences
  - Optimize initialization & communication setup.
- Distributed entity - created and maintained at runtime.

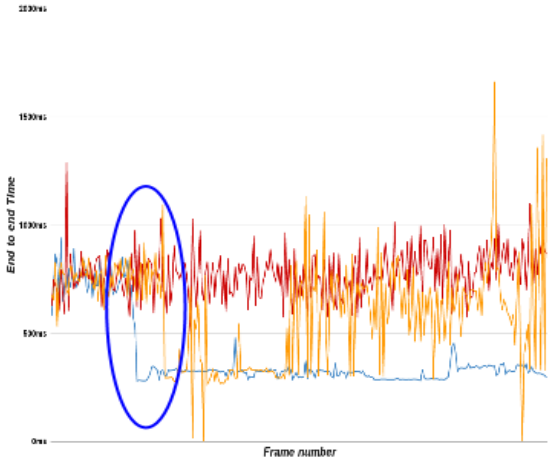
CAF - Operation



Video playback behavior



(i)

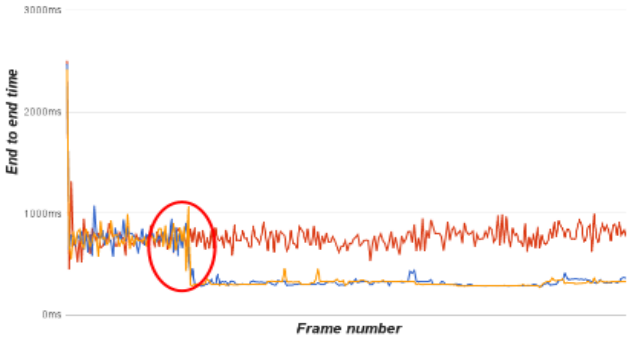


(ii)

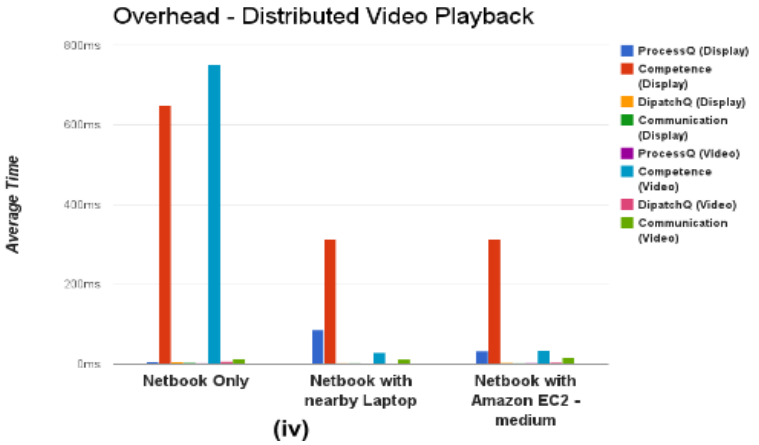
Netbook only

Netbook with nearby laptop

Netbook with Amazon ec2 instance

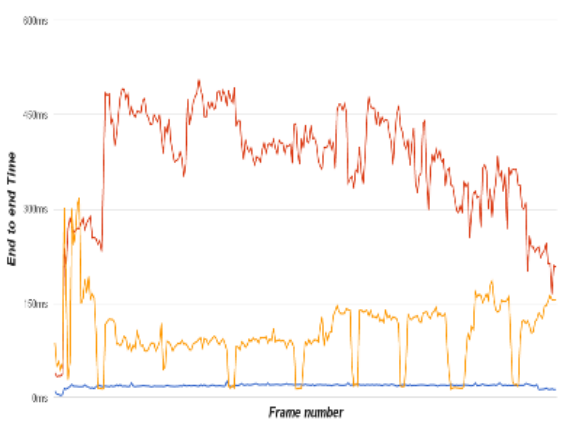


(iii)



(iv)

In-vehicleAR



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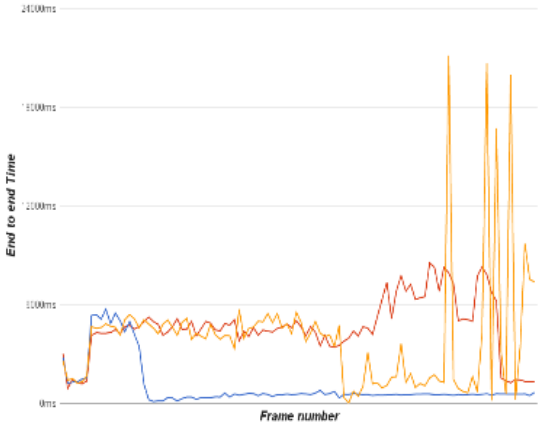

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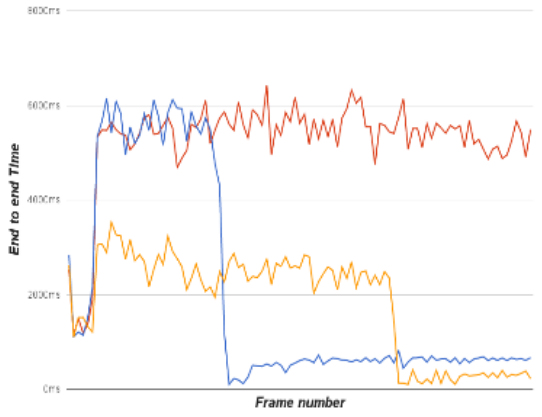

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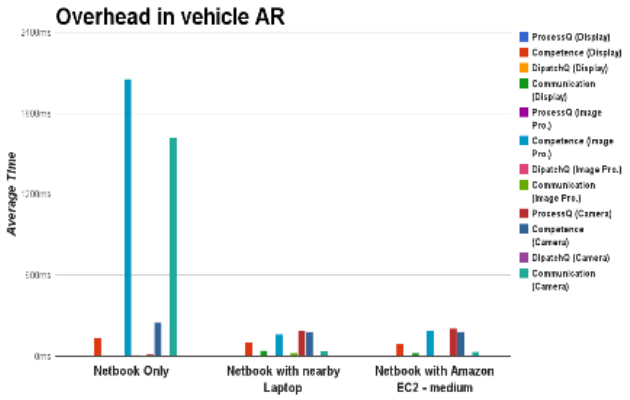


(iv)

Concluding Remarks

- Initial demonstration of feasibility and benefits
  - adapt to dynamism in CIC, leverage unique competencies present on different physical nodes in device cloud, ability to improve performance, energy/extend battery life…
- Continuing evolving capabilities, including specialized data and computation movement techniques, port to Android, dealing with mobility…
- Continued collaboration with Intel

Example - Display

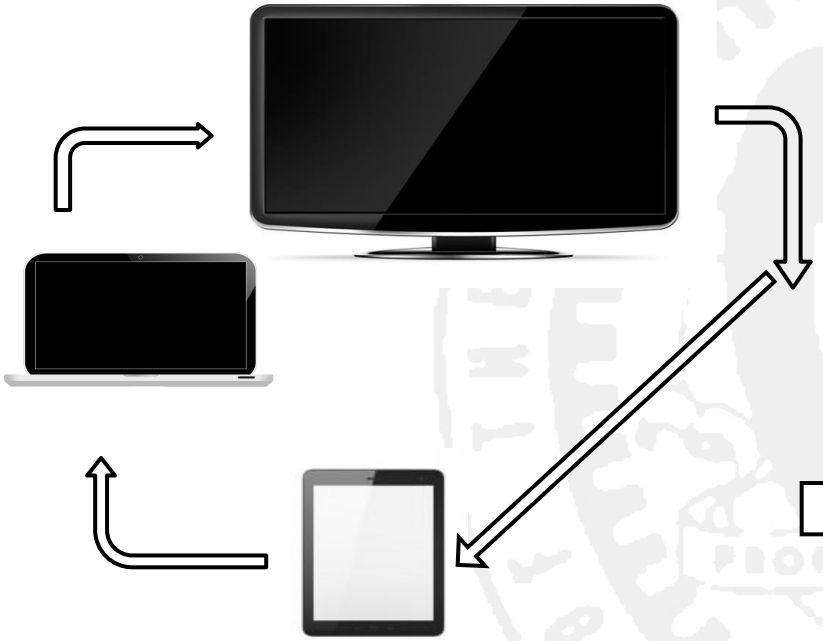
Static part

```
// Functional description
config.vdc_config.raw_id = DISPLAY_TYPE
config.dp_config.type = IMAGE_DISPLAY

// Quality
config.dp_config.max_resolution = 1080 p
config.dp_config.refresh_rate = 60

// Physical properties
config.dp_config.y_size = 27 in
config.dp_config.x_size = 48 in
```

Dynamic part

```
*dl_handle      // library handle
dispatch_addr   // addr to dispatch
process_addr    // addr tp processr

curr_state // availability
```

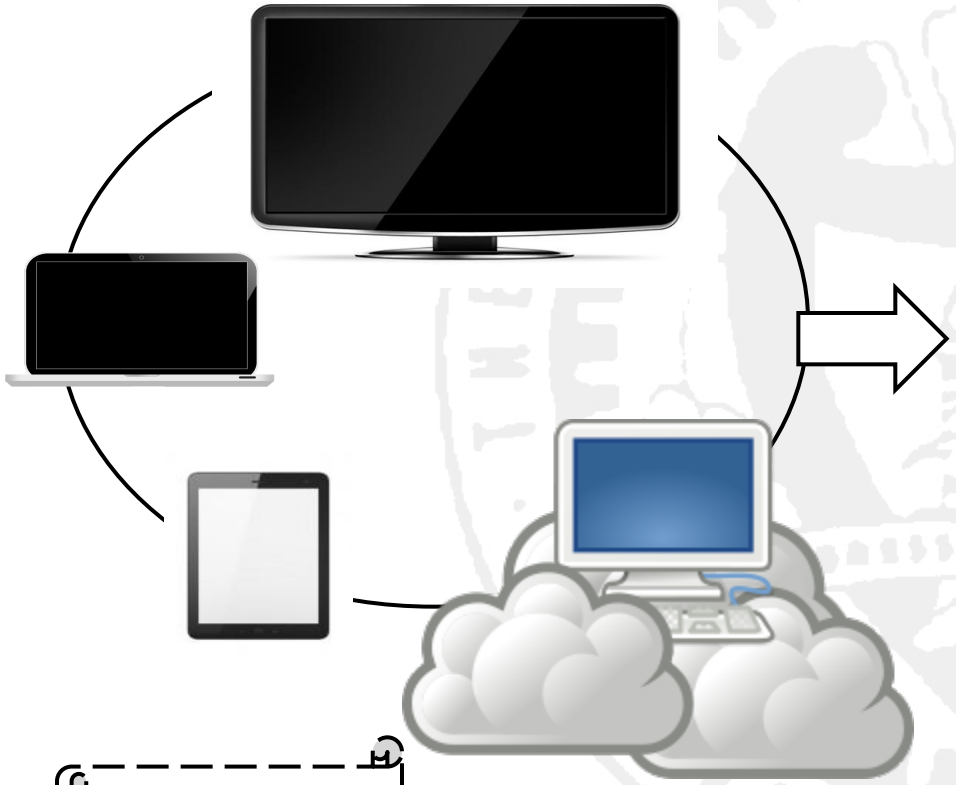
Example - Video playbac



Intent:
Play the video on Biggest screen.

```
// Partially specified competences
comp[0].config.vdc_config.raw_id =FILE
comp[0].config.vdc_config.type = VIDEO

comp[1].config.vdc_config.raw_id
      =VIDEO_DECODE_TYPE
comp[1].config.vdc_config.type = MPEG4
comp[1].config.vdc_config.fps = 60

comp[2].config.dp_config.raw_id = DISPLAY_TYPE;
comp[2].config.dp_config.type = IMAGE_DISPLAY;
comp[2].config.dp_config.res = 1080;
comp[2].config.dp_config.size = 40 ;

// set intent guidelines
intent->guideline.topology = LINEAR
intent->guideline.traversal = SYNC
intent->guideline.tie = NONE
```

Example



Context: Home

Competence instance descriptor

instance; // dynamic part of competence

interface_competence; // static part of competence

Context

// accessible competence instancess

offered_instances;

local_instances;

remote_instances;

cached_instances;

// requested & realized intents

realized_instances;

requested_instances;