Mobile in Cloud

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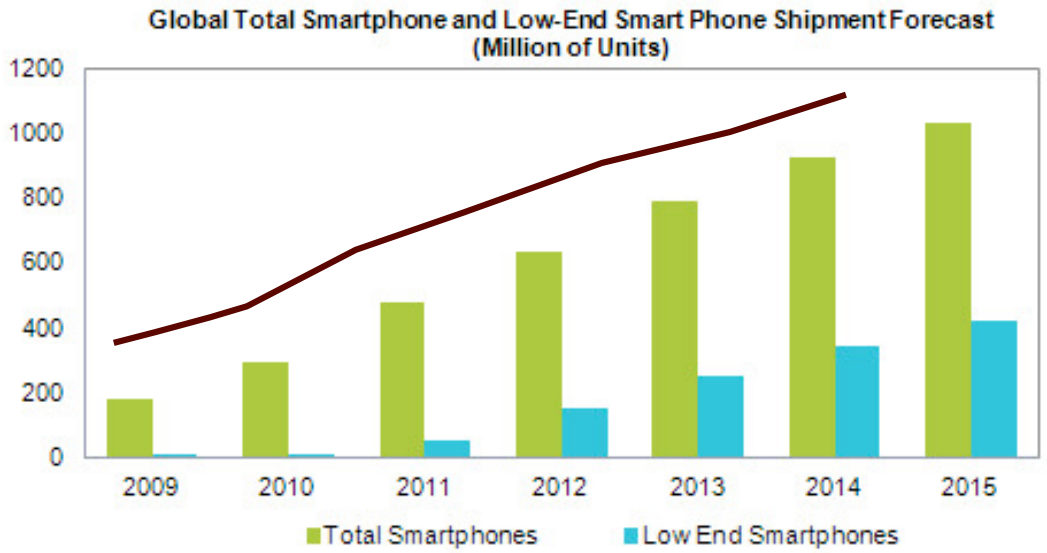
Mobile marketplace grows...



Source: IHS iSuppli October 2011

Mobile marketplace grows...

550,000 devices activated every day

--- Google's 2011 Q2 earnings call

Mobile marketplace grows...

500,000+ iOS Apps

Mobile marketplace grows...

What does phones look like now?

Gigahertz fast CPU

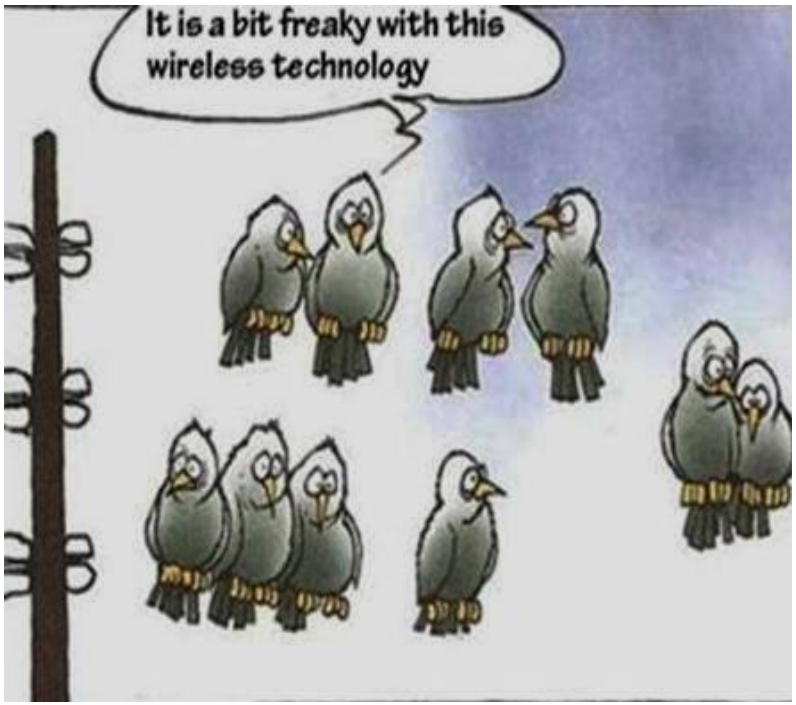
Ubiquitous Internet

Gigabyte Mem

.....

Really Powerful!

Powerful enough? Not always!



Augmented Reality

Speech Recognition

Virus Scan

Mobile streaming

……

Resource constrained

In a cloud-ready era?

Offload the resource demanding tasks onto the cloud

Intuitive!

But...

Practical pending issues...

Platform diversity

Rapid changing environments

Parallelism

Scarce storage

What have been done?

Energy aware:

Optimize energy consumption, by handling the tradeoff between local processing vs. transmission

Eduardo Cuervo et al., MAUI: Making Smartphones Last Longer with Code Offload, MobiSys, 2010

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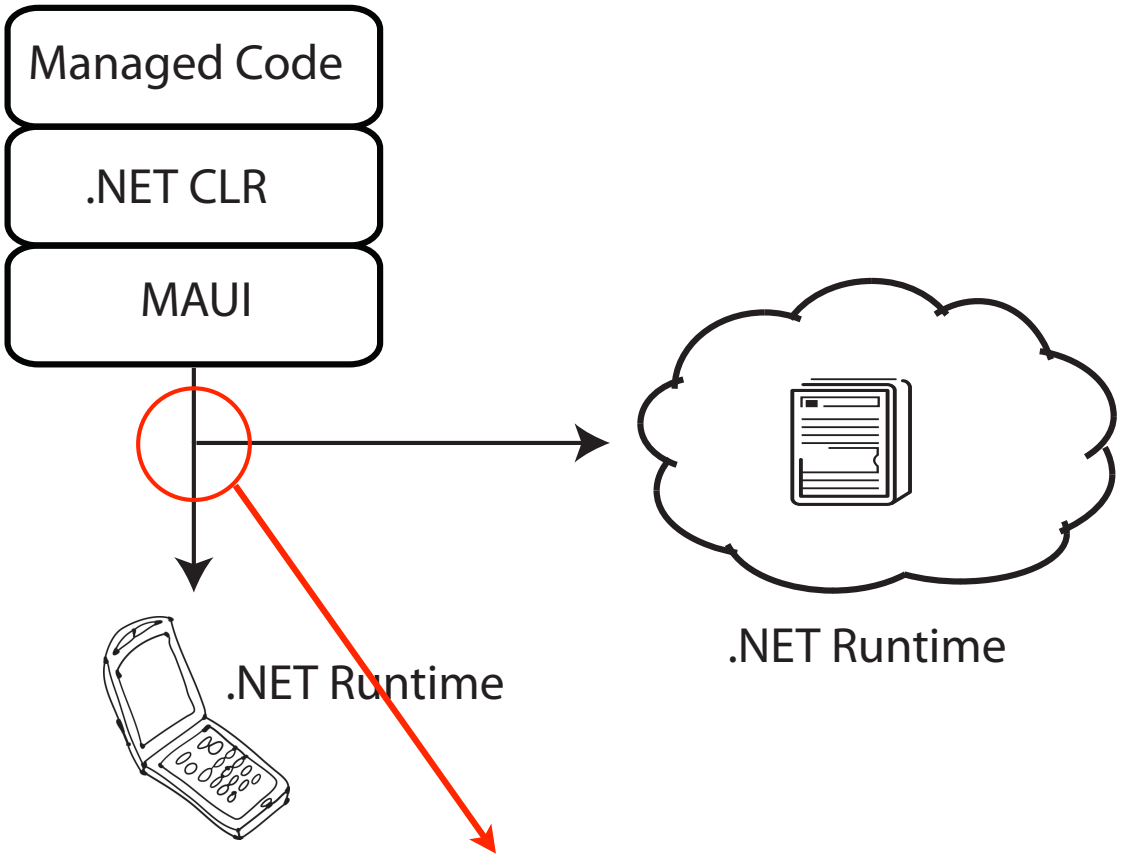

Optimization Problem!

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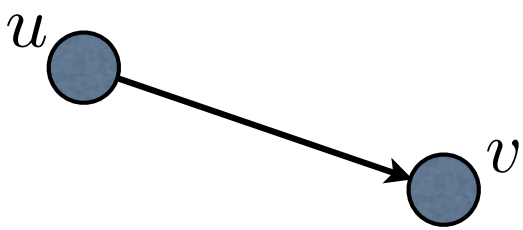

$G = (V, E)$	Call stack of the execution
$v \in V$	A method in the call stack
$e = (u, v)$	Invocation of method v from u
E_u^l	Energy needed for local execution
T_u^l	Time needed for local execution
T_u^r	Time needed for remote execution
$B_{u,v}$	Time needed for state transfer from u to v
$C_{u,v}$	Energy needed for state transfer from u to v
I_u	Indicate whether method u is executed locally
r_u	Indicate whether method u is remoteable

Eduardo Cuervo et al., MAUI: Making Smartphones Last Longer with Code Offload, MobiSys, 2010

$$\text{maximize} \sum_{v \in V} I_v \times E_v^l - \sum_{(u,v) \in E} |I_u - I_v| \times C_{u,v}$$

$$\text{such that:} \sum_{v \in V} ((1 - I_v) \times T_v^l) + (I_v \times T_v^r))$$

$$+ \sum_{(u,v) \in E} (|I_u - I_v| \times B_{u,v}) \leq L$$

$$\text{and} \qquad I_v \leq r_v, \ \forall v \in V$$

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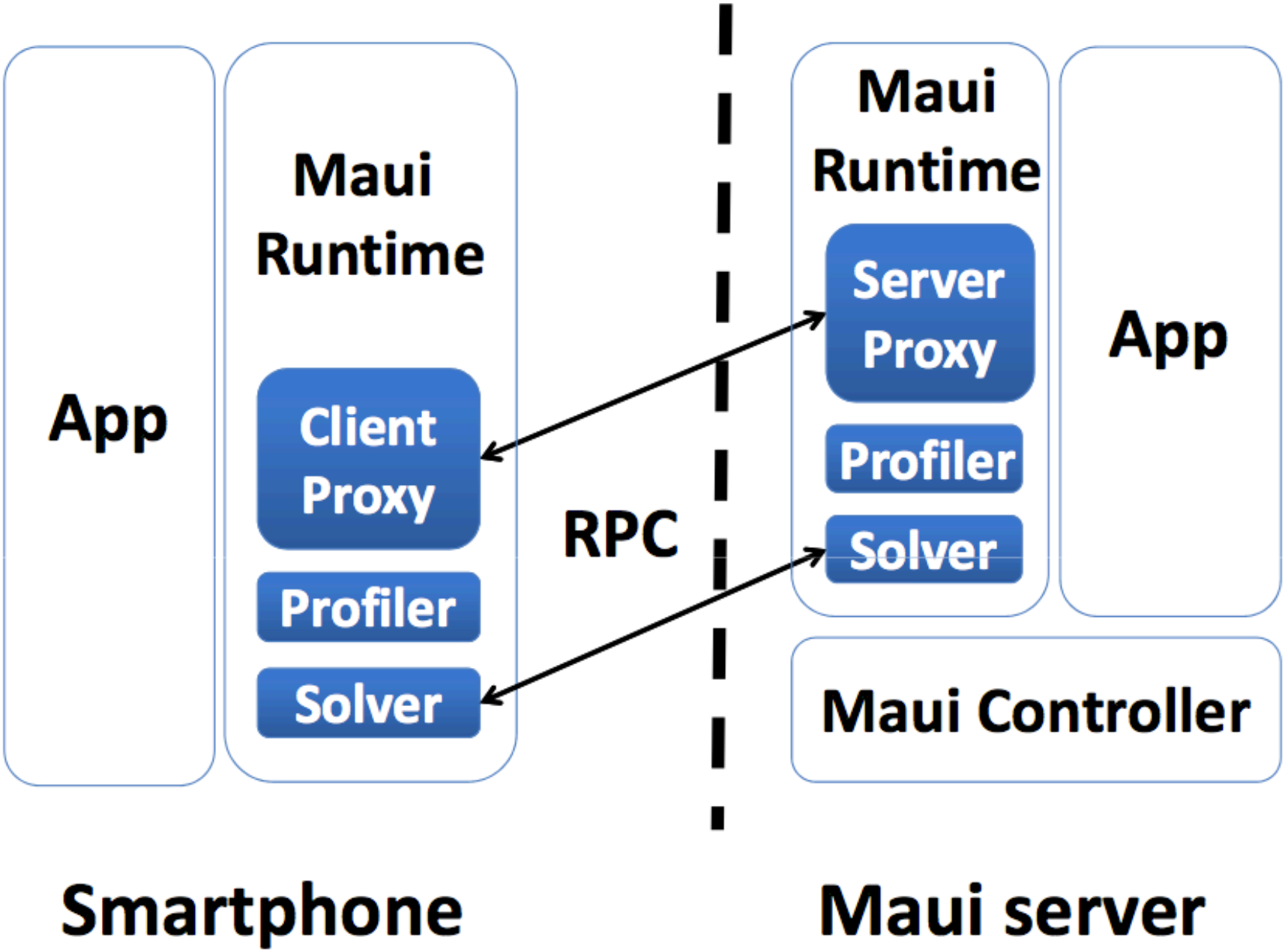


Eduardo Cuervo et al., MAUI: Making Smartphones Last Longer with Code Offload, MobiSys, 2010

Profiles too coarse-grained information

Portability issues

Parallelism

Nontrivial ILP

What have been done? (con't)

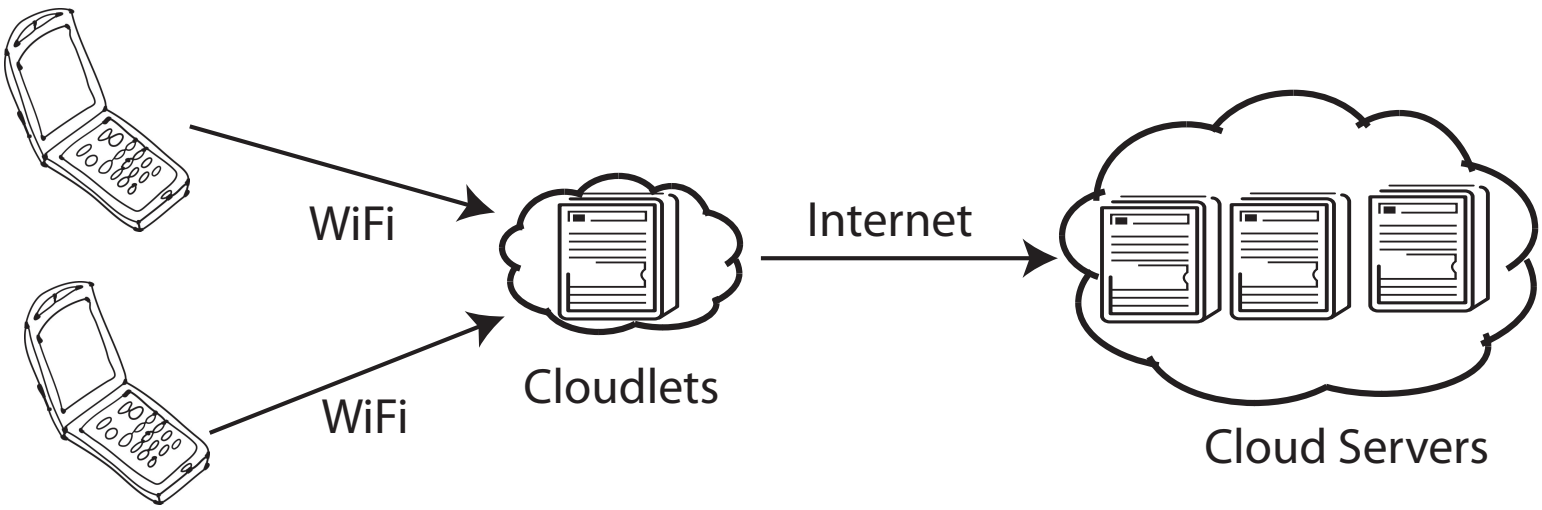
Portability:

Mobile Virtualization

Mahadev .S et al., The Case for VM-based Cloudlets in Mobile Computing, IEEE Pervasive Computing, 2009

Byung-Gon Chun et al.,Elastic Execution between Mobile Device and Cloud, EuroSys, 2011

Mahadev .S et al., The Case for VM-based Cloudlets in Mobile Computing, IEEE Pervasive Computing, 2009



Latency sensitive

No internet connection

Mahadev .S et al., The Case for VM-based Cloudlets in Mobile Computing, IEEE Pervasive Computing, 2009

Two different VM Solutions

Complete VM migration

Full-featured VM environment on device

The whole image need to be migrated

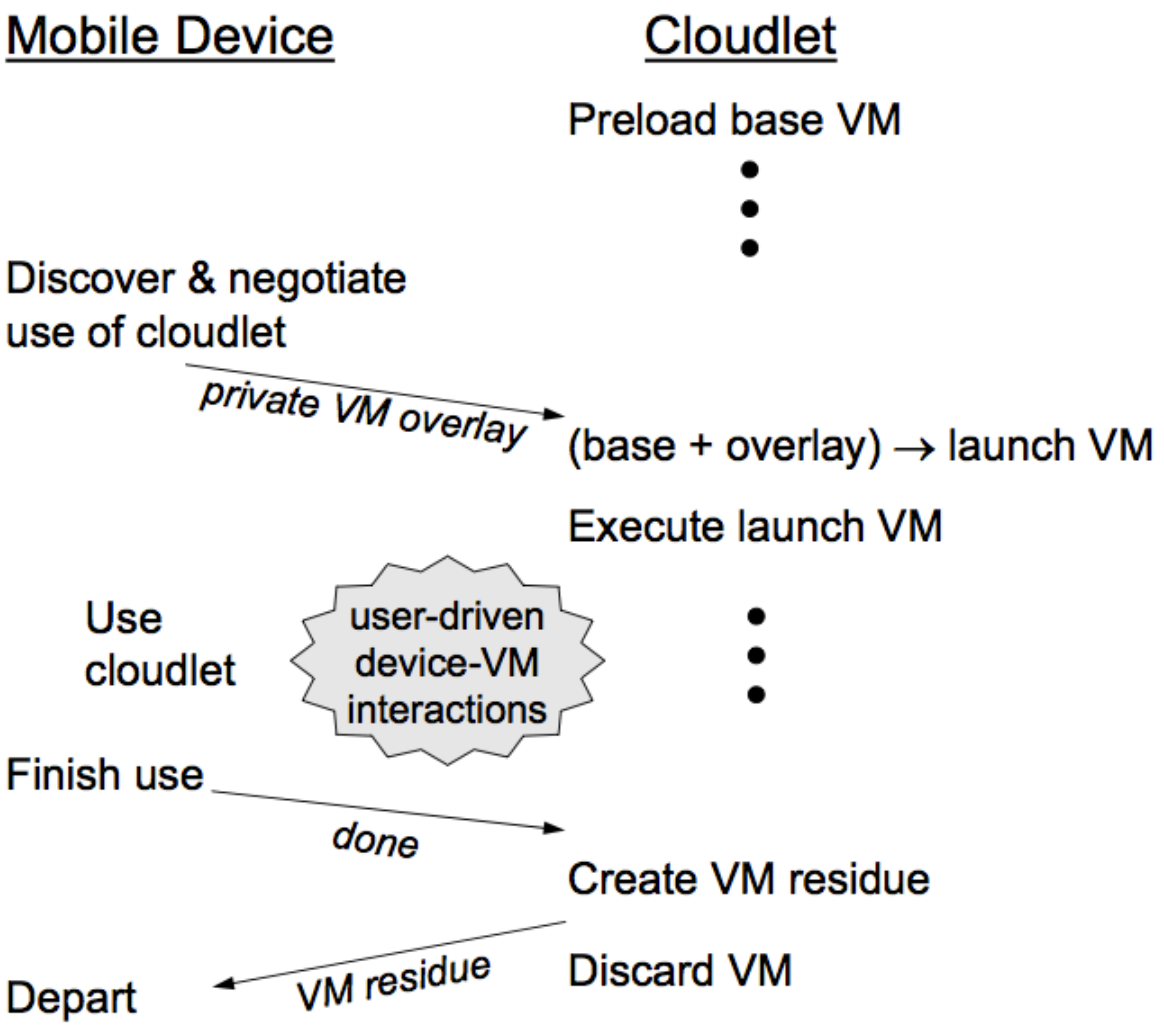
VM split overlay

Don't have to maintain full-featured VM on device

Delta migration

Mahadev .S et al., The Case for VM-based Cloudlets in Mobile Computing, IEEE Pervasive Computing, 2009

VM split overlay



Mahadev .S et al., The Case for VM-based Cloudlets in Mobile Computing, IEEE Pervasive Computing, 2009

Thin client

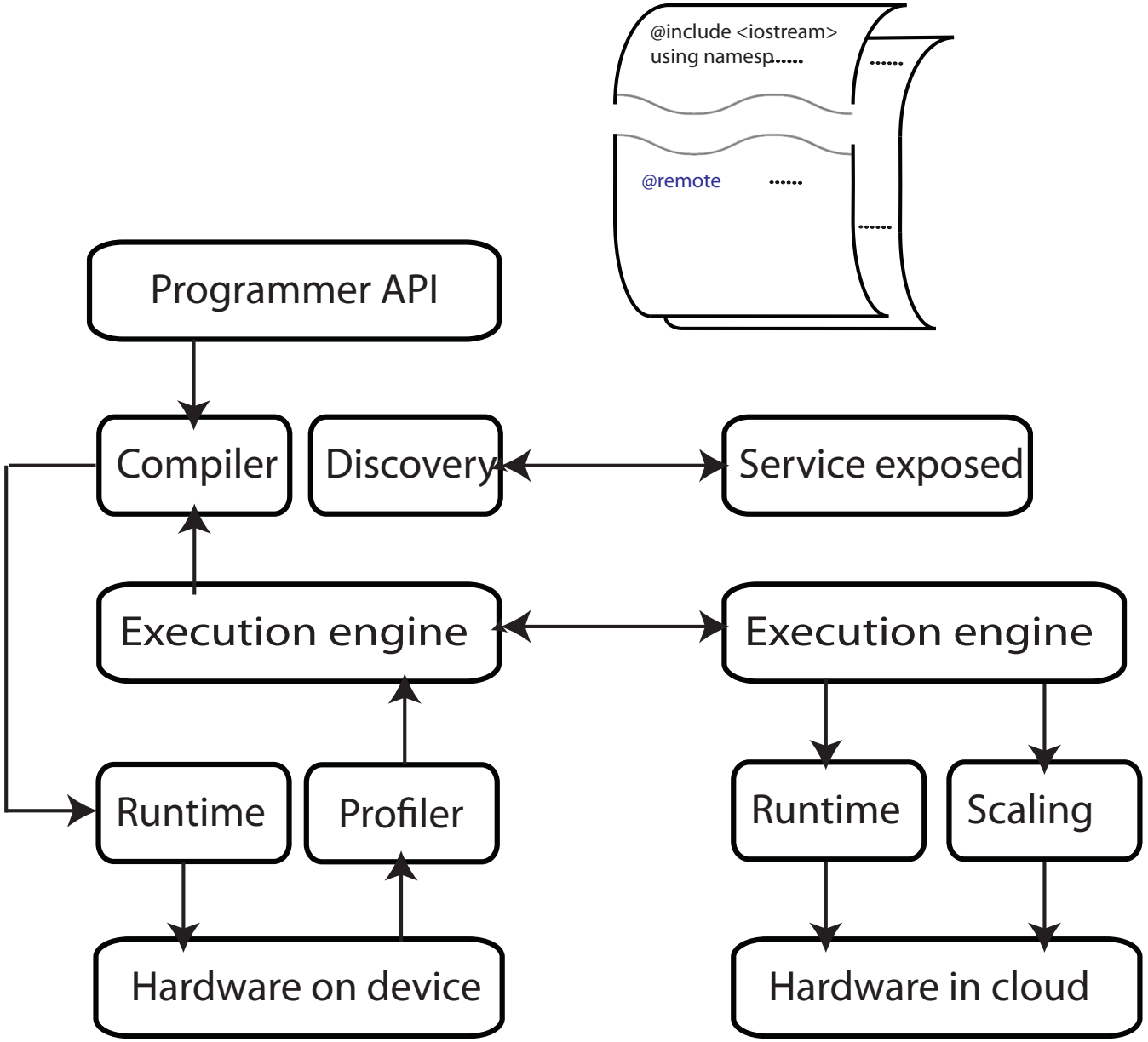
Difficult to suspend/resume once launched

Security issues

What have been done? (con't)

General Framework

Dynamic offload to enable parallel execution both locally and remotely. Suspend/Resume, replication on demand.


@include <iostream>
using namesp.....
.....
@remote .....
.....
Programmer API
Compiler
Discovery
Service exposed
Execution engine
Execution engine
Runtime
Profiler
Runtime
Scaling
Hardware on device
Hardware in cloud

Q and A?