

# Engineering Human-based Services in Hybrid Computing Systems

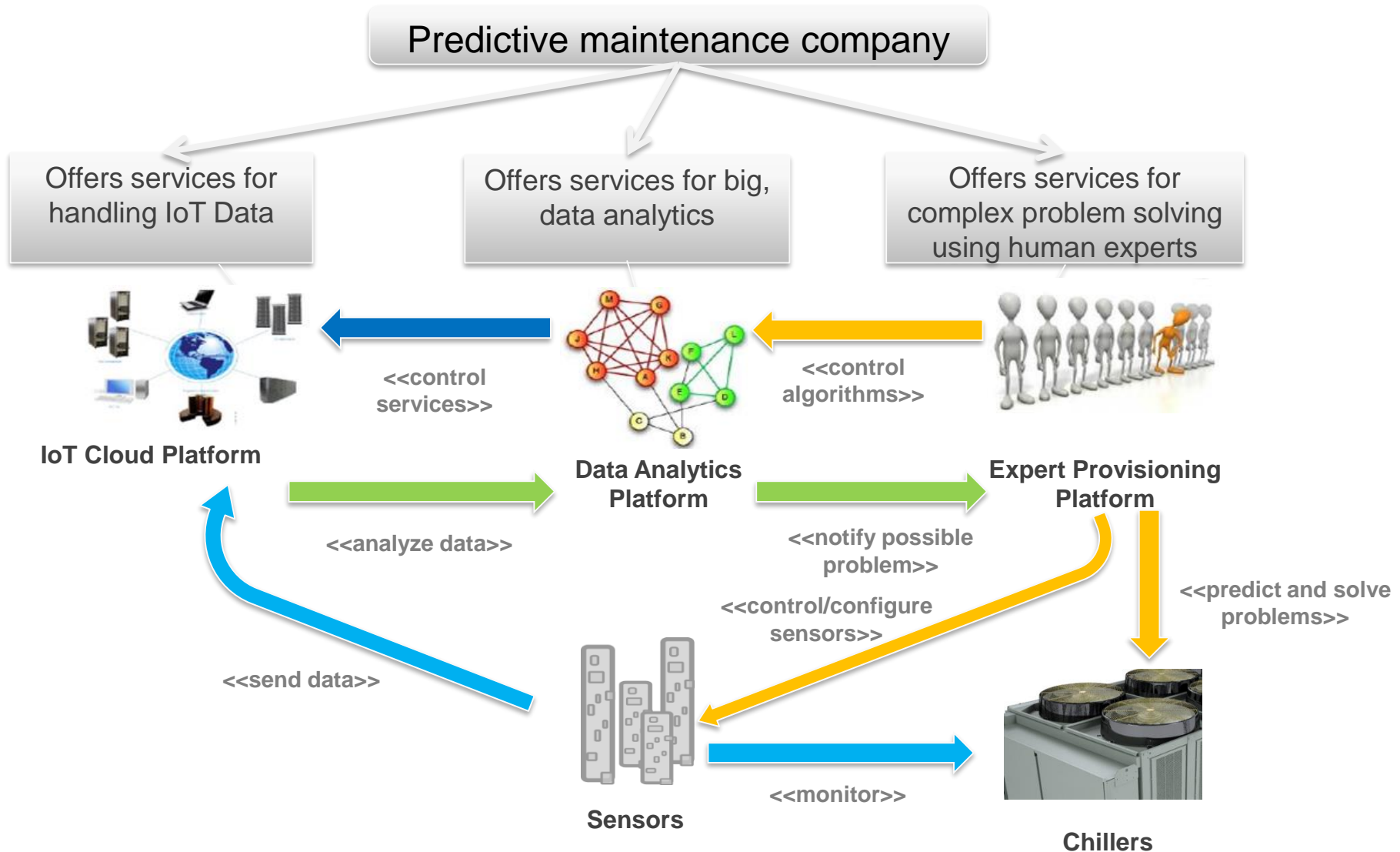
Hong-Linh Truong  
Faculty of Informatics, TU Wien

[hong-linh.truong@tuwien.ac.at](mailto:hong-linh.truong@tuwien.ac.at)  
[http://www.infosys.tuwien.ac.at/staff/truong  
@linhsolar](http://www.infosys.tuwien.ac.at/staff/truong@linhsolar)

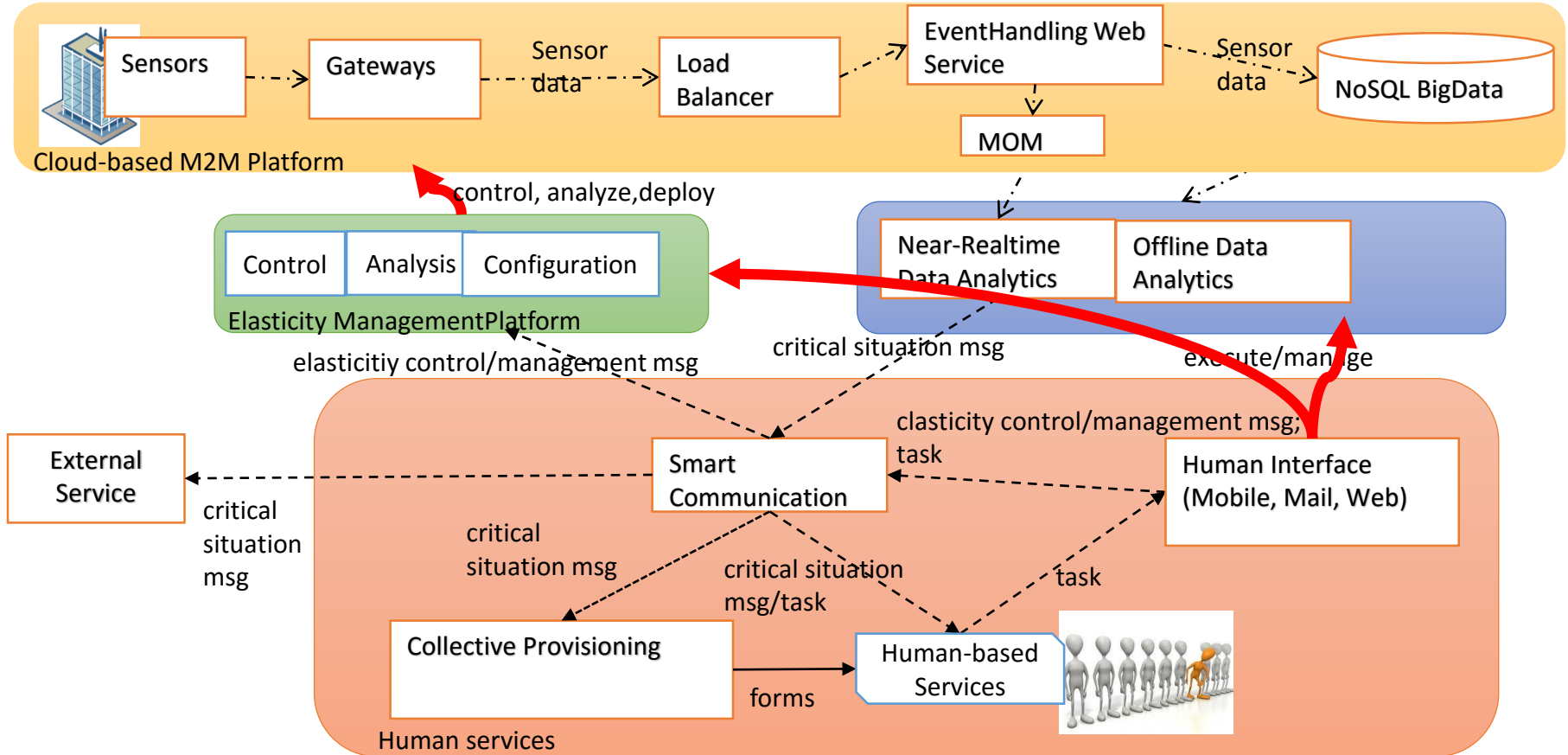
# What this lecture is about?

- Not about crowdsourcing here
  - From service engineering perspectives
- Motivating scenarios
- Human service units
- Provisioning and employing human service units
  - some frameworks

# Scenario



# Integrated systems of software, things and people services



# Hybrid intelligence

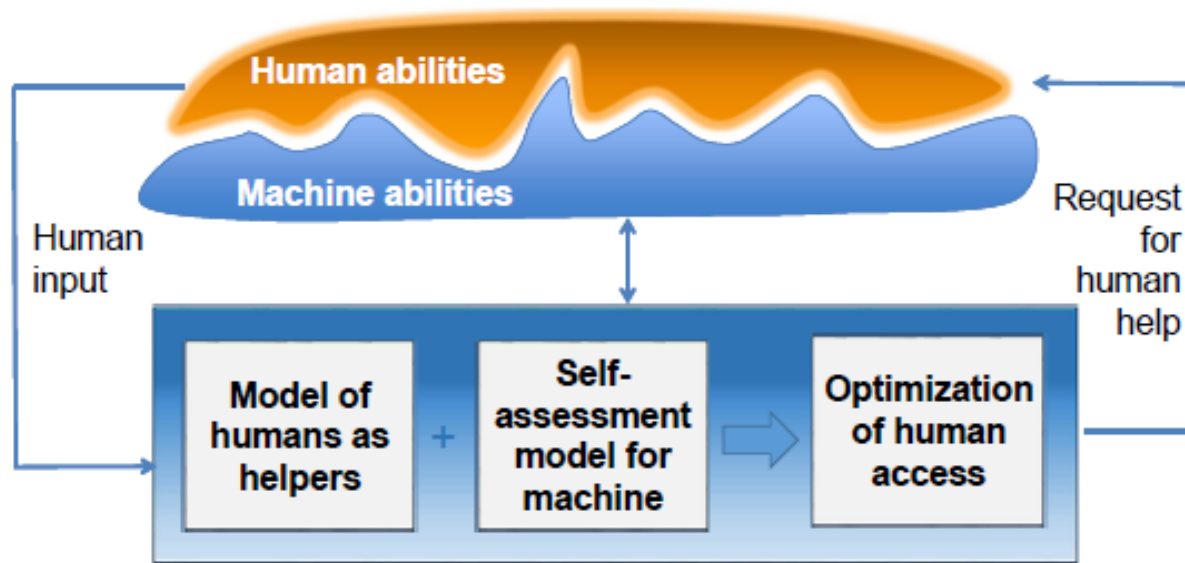
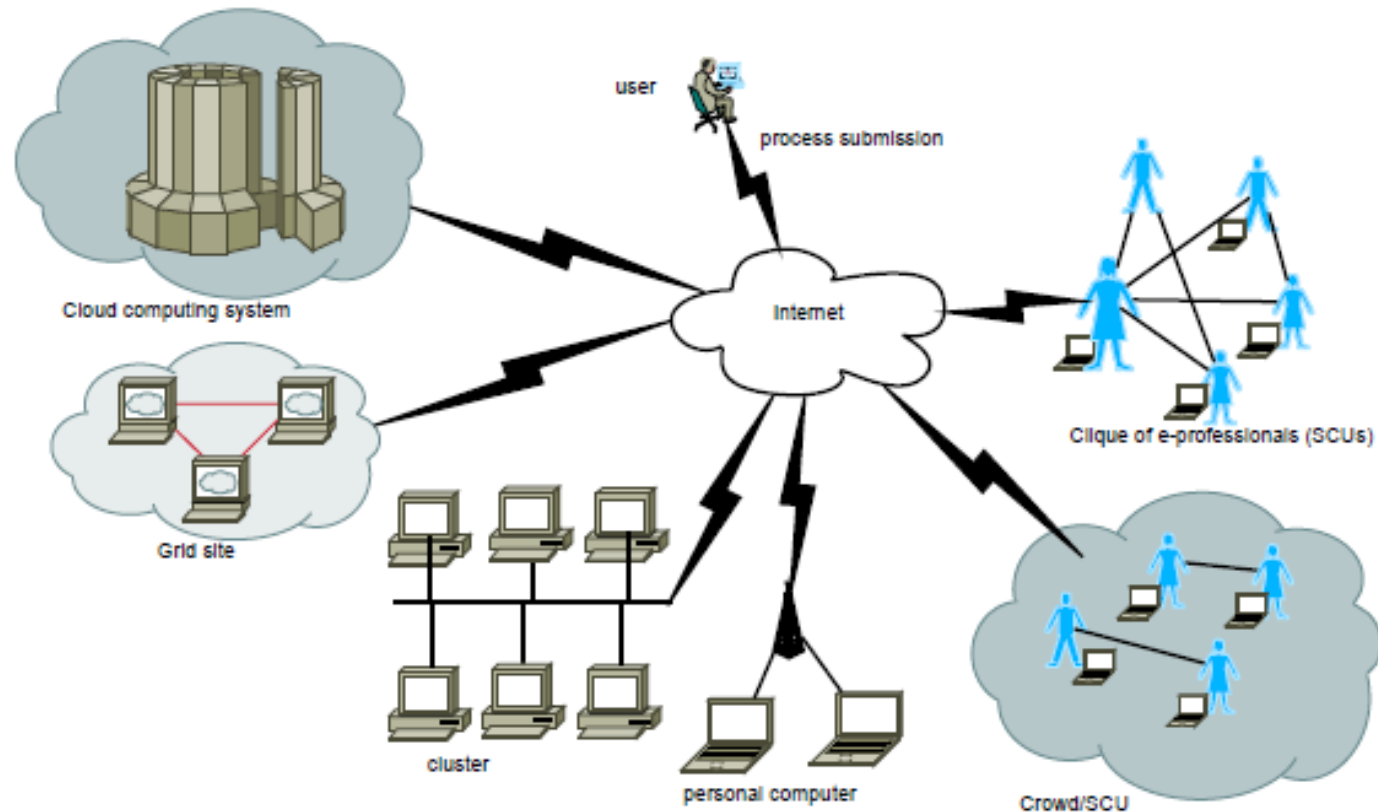


Figure 1: Reasoning capabilities for hybrid intelligence.

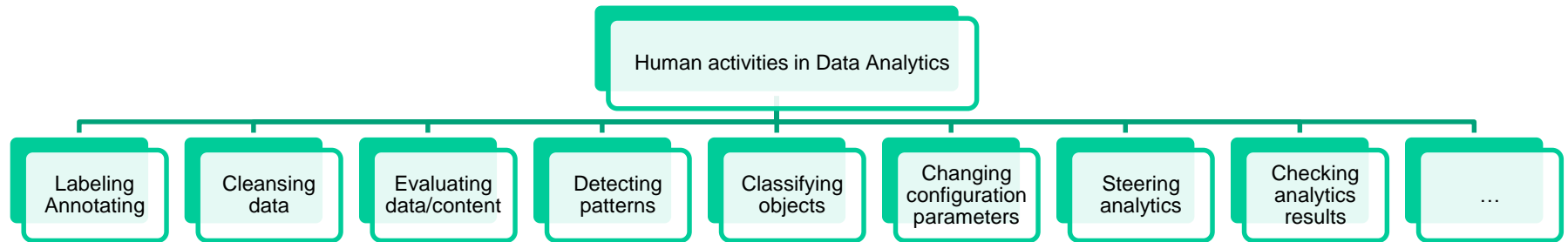
Source: Ece Kamar. 2016. Directions in hybrid intelligence: complementing AI systems with human intelligence. In *Proceedings of the Twenty-Fifth International Joint Conference on Artificial Intelligence (IJCAI'16)*, Gerhard Brewka (Ed.). AAAI Press 4070-4073.  
<https://www.microsoft.com/en-us/research/wp-content/uploads/2016/11/hi.pdf>

# Human-based services for solving complex problems (2)



But how to program human-based services and software-based services together?

# Example: some common tasks in data analytics



We should look more domain-specific tasks than typical crowdsourcing tasks (e.g., for data collection)

Domains: IIoT, e.g., predictive maintenance and remote analytics

# Human service units in data analytics -- functions

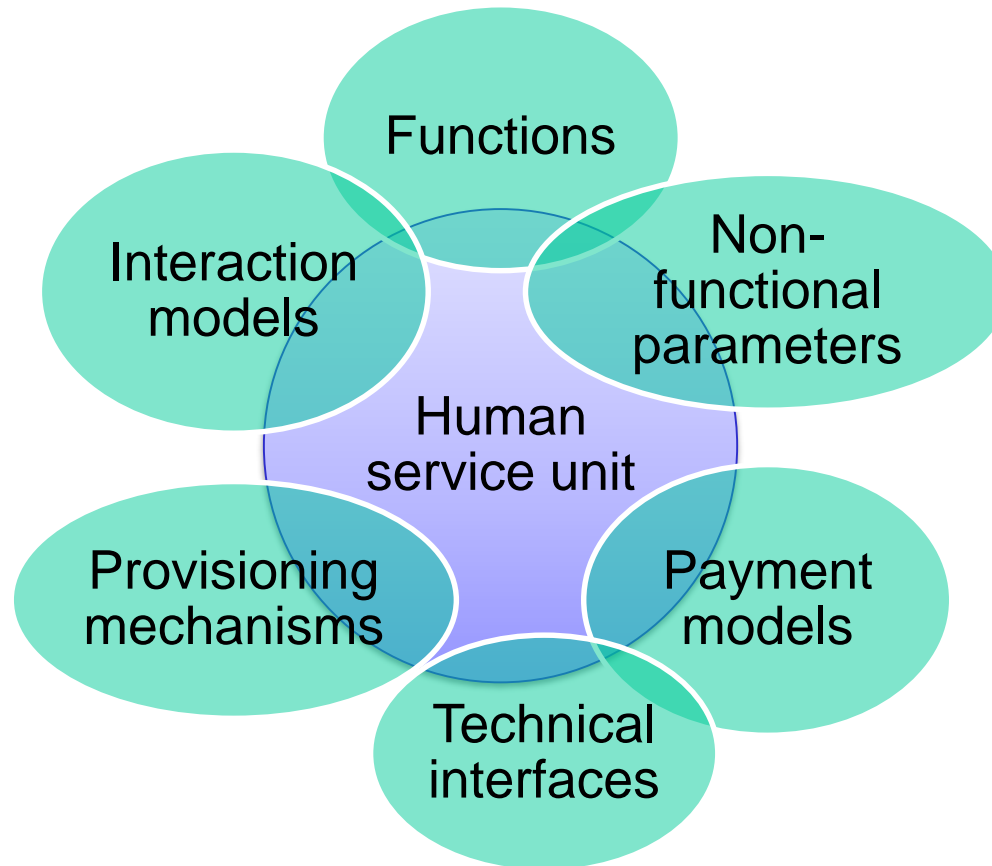
- Evaluating: is the quality of picture good?
- Classifying: is it a man's or a woman's picture?
- Detecting: any unidentified object in a picture?
- Labeling: adding location information of a picture
- Cleansing: remove duplicated pictures
- Steering: the quality of picture is bad, should we continue to merge it with others?
- Evaluating results

How to model such functions for human units ? E.g., with REST, serverless, or tasks through queue?



# HUMAN SERVICE UNITS

Human acting as a „service unit“



# Forms of human services

- Individual Compute Unit (ICU)
  - An individual is treated like „a processor“ or “functional unit“. A service can wrap human capabilities to support the communication and coordination of tasks
- Hybrid Compute Unit (Collective) (HCU)
  - A set of people and software that are initiated and provisioned as a service for solving tasks
- Services interfaces can be built
- Different pricing models and different quality models

# Human service units – provisioning mechanisms (1)



- An infrastructure can be introduced for accessing many ICUs in a crowd
  - Allow people to register their service unit capabilities
  - Facilitate communication, task bidding, retrieval and result delivery
  - Act like a marketplace: multiple providers and multiple consumers

# Human service units – provisioning mechanisms (2)



- An „infrastructure-as-a-service“ for ICUs
  - Facilitate communication, task retrieval and result delivery
  - Single ICU as-a-service provider and multiple consumers

# MTurk as an ICU provider

Your Account
HITS
Qualifications

Introduction | Dashboard | Status | Account Settings

**Mechanical Turk is a marketplace for work.**

We give businesses and developers access to an on-demand, scalable workforce. Workers select from thousands of tasks and work whenever it's convenient.

**1,102,549 HITS** available. [View them now.](#)

## Make Money by working on HITS

HITS - *Human Intelligence Tasks* - are individual tasks that you work on. [Find HITS now.](#)

As a Mechanical Turk Worker you:

- Can work from home
- Choose your own work hours
- Get paid for doing good work



or [learn more about being a Worker](#)

## Get Results from Mechanical Turk Workers

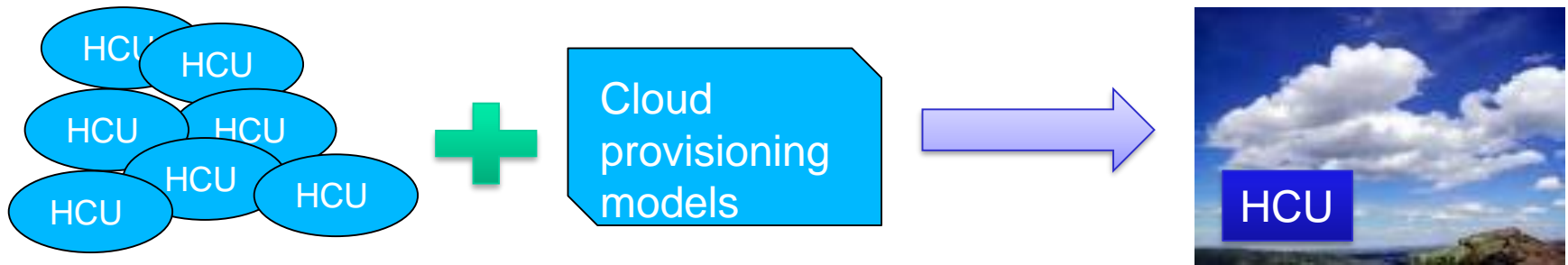
Ask workers to complete HITS - *Human Intelligence Tasks* - and get results using Mechanical Turk. [Get Started.](#)

As a Mechanical Turk Requester you:

- Have access to a global, on-demand, 24 x 7 workforce
- Get thousands of HITS completed in minutes
- Pay only when you're satisfied with the results

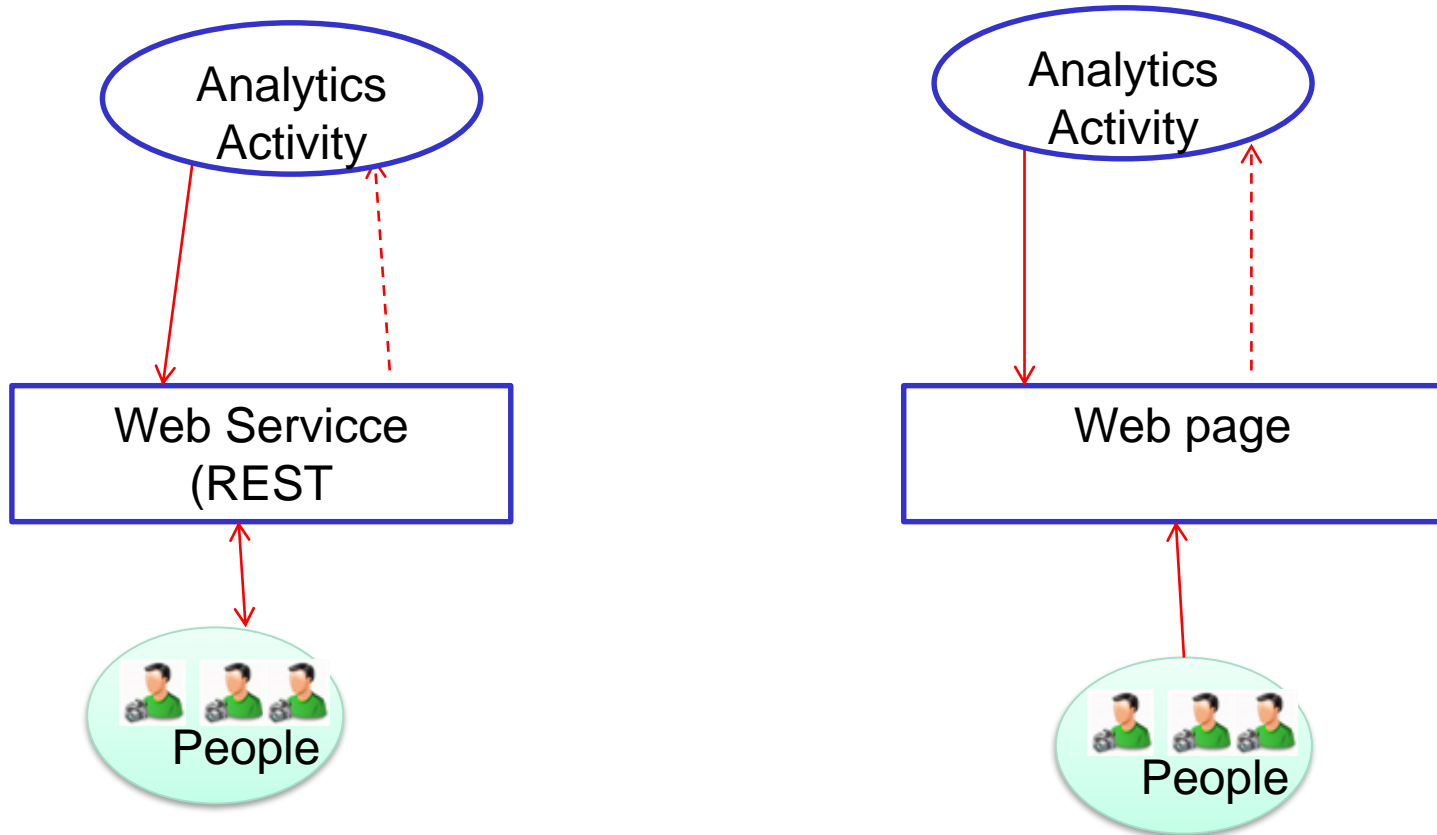


# Human service units – provisioning mechanisms (3)



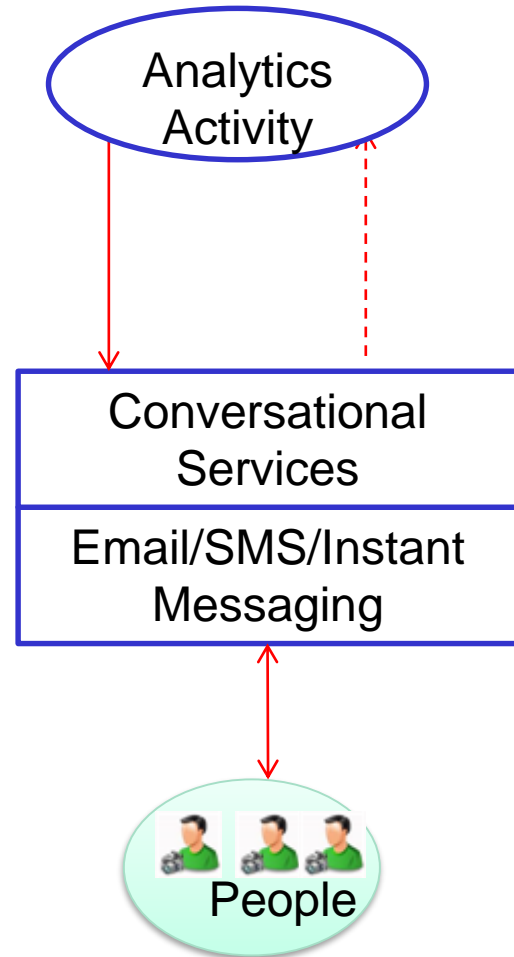
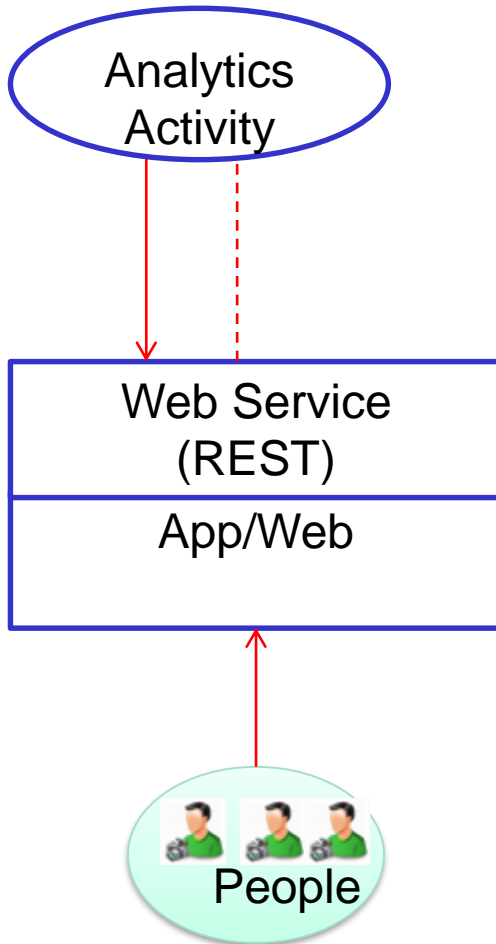
- An „infrastructure-as-a-service“ for HCUs
  - Facilitate communication, task retrieval and result delivery
  - Single HCU as-a-service provider and multiple consumers

# Human service units – technical interfaces (1)

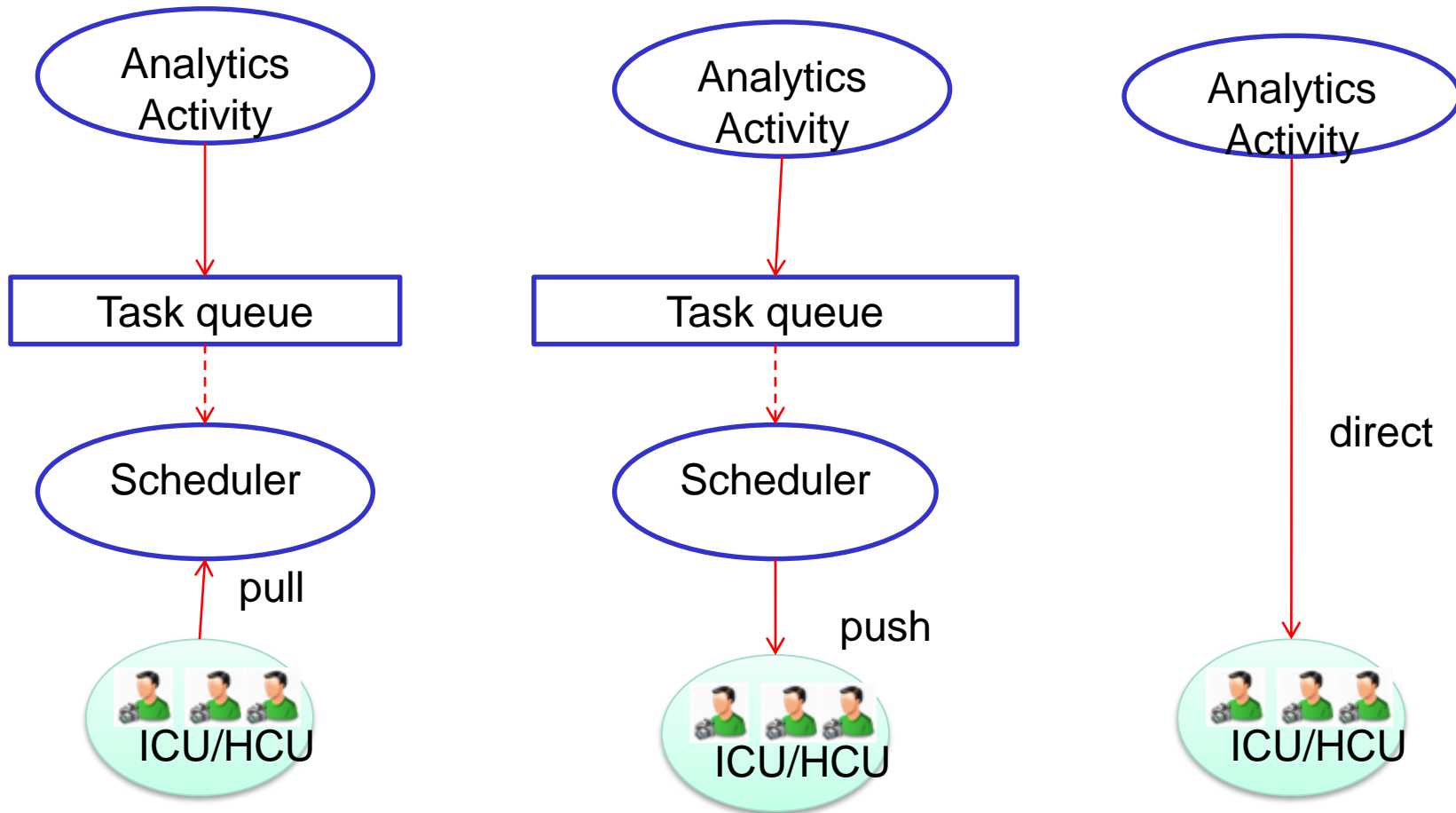




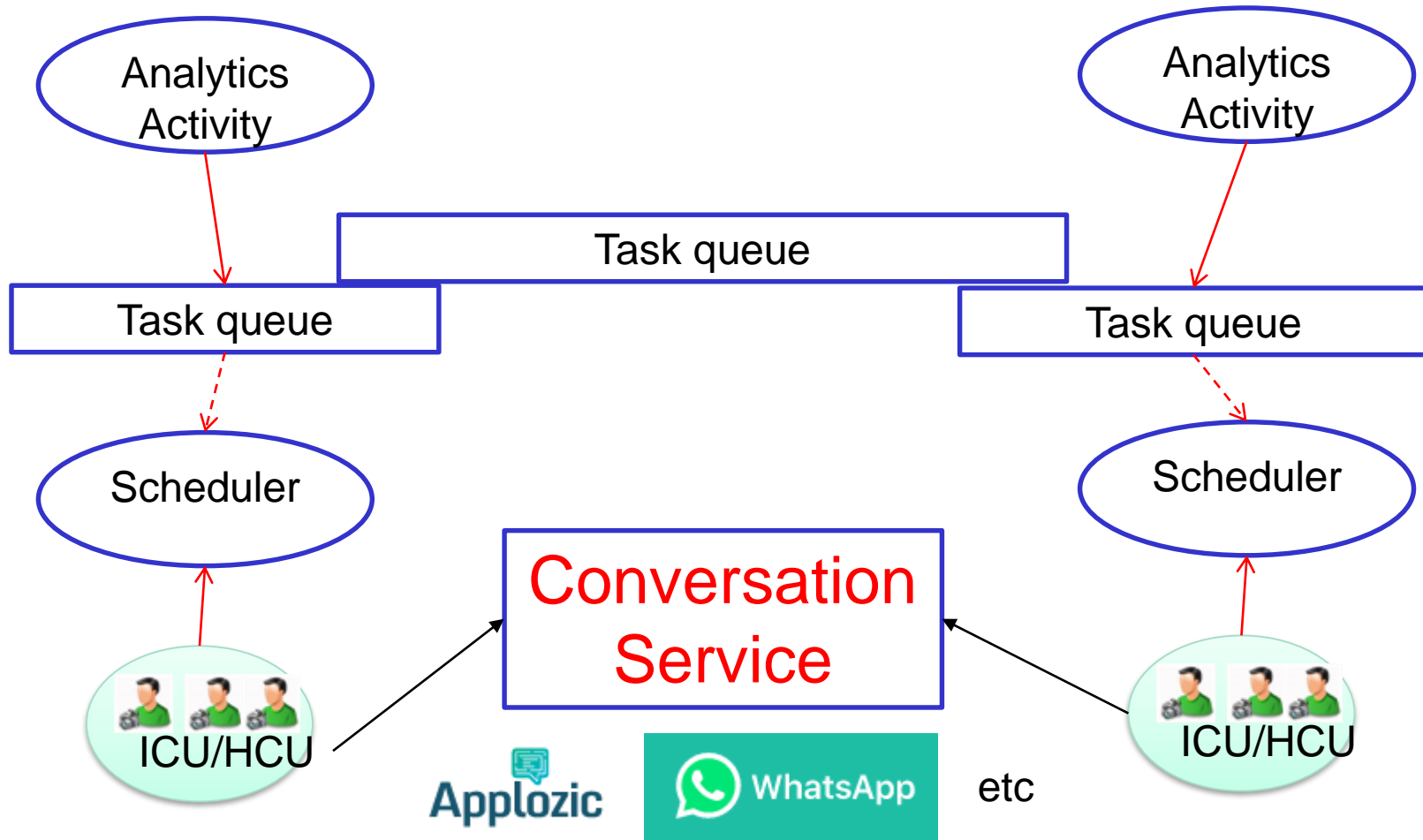
# Human service units – technical interfaces (2)



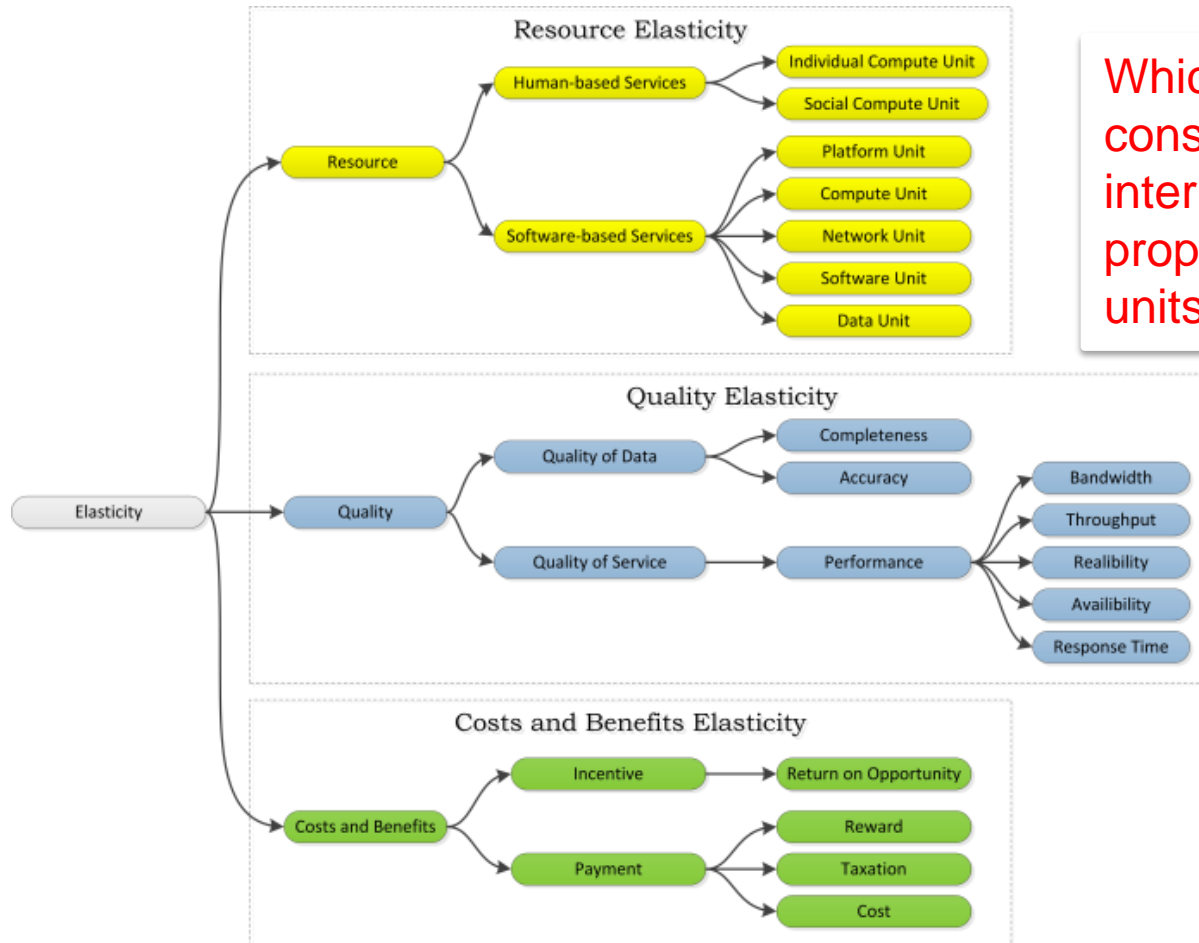
# Human service units – interaction model



# Conversational Features



# Human service units -- quality/cost



Which are important considerations when interpreting non-functional properties for human service units?

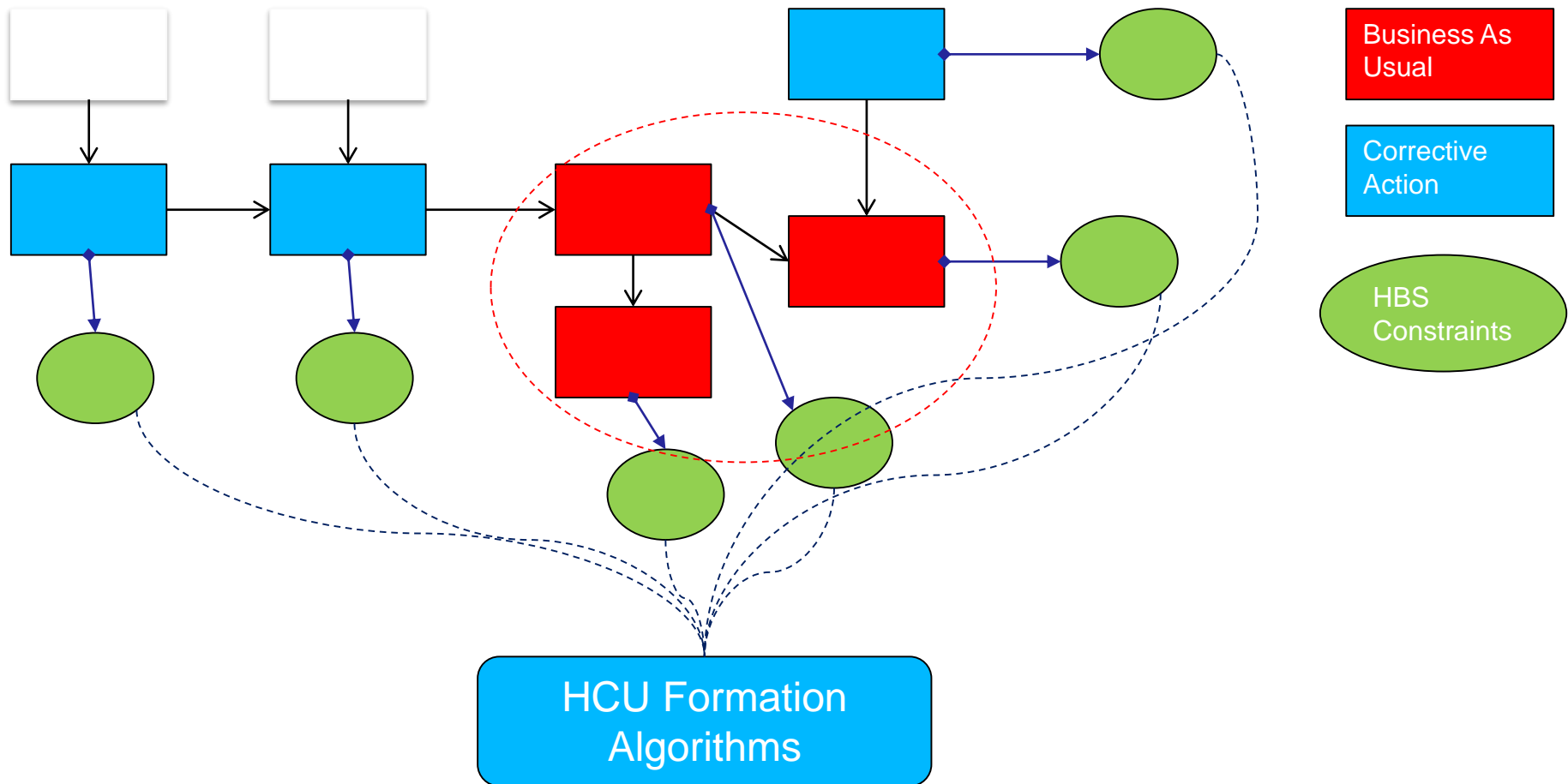
# Incorporating human units into complex processes

- How to provision and employ human compute units?
- How to select human units?
- Where to place human units in data analytics and why?
- How to monitor and test human units in data analytics?

# Selecting human units

- Do not select at all
  - Let human units bid the tasks
    - E.g., in crowdsourcing platforms
- Static/fix mapping
  - E.g., using static information for human-task mapping
- Simple selection techniques
  - Using the requirement of the task to find the suitable human units based on their capabilities
- Complex selection techniques
  - Utilizing complex dependency graphs to find suitable human units

# Selecting HCU based on task graphs



Hong Linh Truong, Shahram Dustdar, Kamal Bhattacharya: Programming Hybrid Services in the Cloud. ICSSOC 2012: 96-110

# Placement techniques for human units

- Usually at design time the developer/designer decides
  - Where to put human units
  - Where some triggers should be put in order to invoke human units if needed
- At runtime
  - Find suitable human units
  - Invoke human units
- Placement of human units
  - Application-specific
  - Needs automatic algorithms and supporting tools



# **PROVISIONING AND EMPLOYING HUMAN SERVICE UNITS-- SOME FRAMEWORKS**

# Approaches

- Software perform task routing and management
- Software perform the work and invoke human only needed
- Humans and software working together

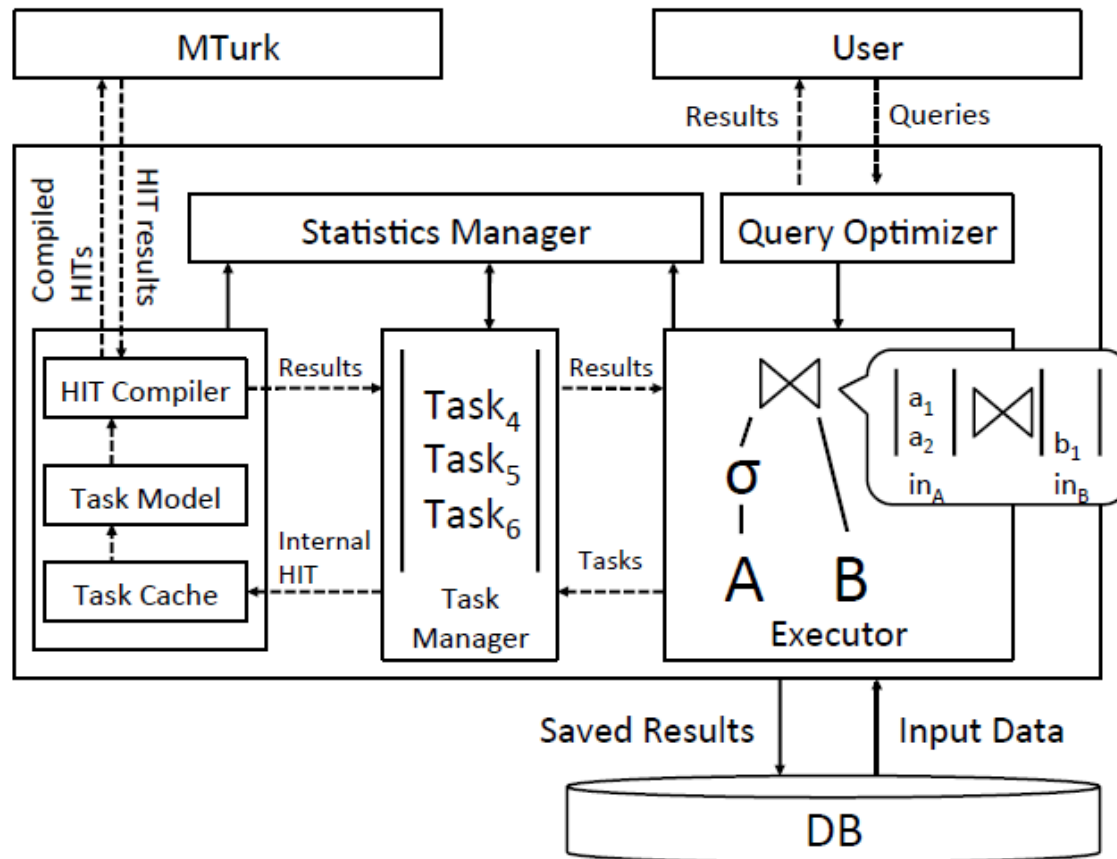
# Qurk system architecture (1)

```
SELECT c.name
FROM celeb c JOIN photos p
ON samePerson(c.img,p.img)
AND POSSIBLY gender(c.img) = gender(p.img)
AND POSSIBLY hairColor(c.img) = hairColor(p.img)
AND POSSIBLY skinColor(c.img) = skinColor(p.img)
```

```
TASK gender(field) TYPE Generative:
  Prompt: "<table><tr> \
          <td><img src='%s'> \
          <td>What is this person's gender? \
          </table>", tuple[field]
  Response: Radio("Gender",
                  ["Male","Female",UNKNOWN])
  Combiner: MajorityVote
```

Source: Adam Marcus, Eugene Wu, David Karger, Samuel Madden, and Robert Miller. 2011. Human-powered sorts and joins. Proc. VLDB Endow. 5, 1 (September 2011), 13-24.

# Qurk system architecture (2)



Source: Adam Marcus, Eugene Wu, David Karger, Samuel Madden, and Robert Miller. 2011. Human-powered sorts and joins. Proc. VLDB Endow. 5, 1 (September 2011), 13-24.

# Jabberwocky approach (1)

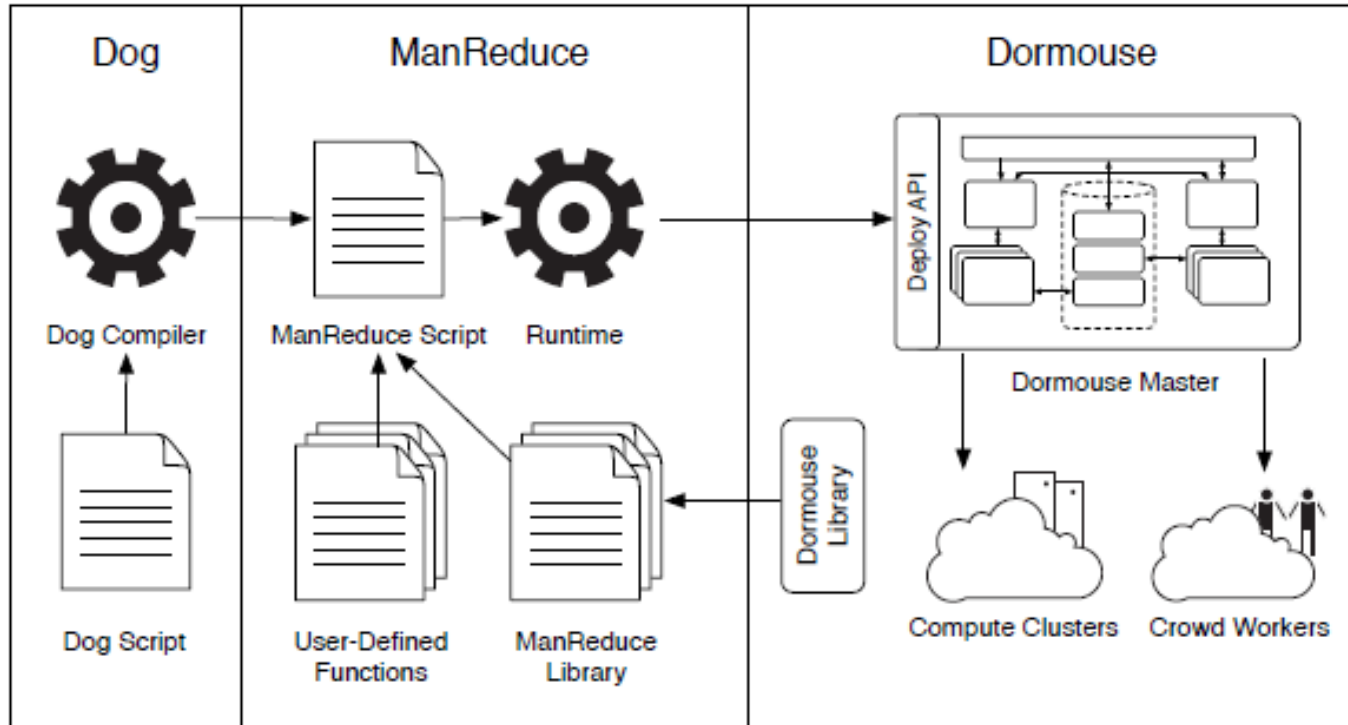


Figure 1: Overview of Jabberwocky

Source: Salman Ahmad, Alexis Battle, Zahan Malkani, Sepandar D. Kamvar: **The jabberwocky programming environment for structured social computing**. UIST 2011: 53-64

# Jabberwocky approach (2)

```

1  map :name => :extract_disease_facts do |key,
    value|
2    facts = RiskExtractor.extract (value)
3
4    for fact in facts do
5      emit (fact["disease"], fact["risk_factor"
6        ])
7    end
8  end
9
10 reduce :name => :summarize do |key, values|
11
12   task = SummarizeFacts.prepare
13   :task_name => "Summarize disease risks:
14     #{key}"
15   task.facts = values
16   task.ask do |answer|
17     emit (key, answer)
18   end
19
20 end

```

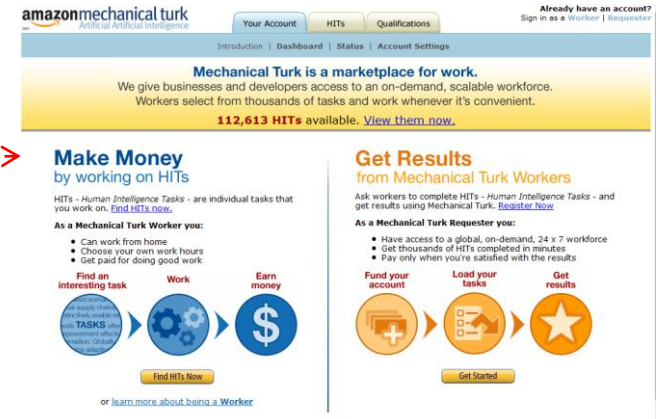
Source: Salman Ahmad, Alexis Battle, Zahan Malkani, Sepandar D. Kamvar: **The jabberwocky programming environment for structured social computing**. UIST 2011: 53-64

# Automan approach

```

1  import edu.umass.cs.automan.adapters.MTurk._
2
3  object SimpleProgram extends App {
4    val a = MTurkAdapter { mt =>
5      mt.access_key_id = "XXXX"
6      mt.secret_access_key = "XXXX"
7    }
8
9    def which_one() = a.RadioButtonQuestion { q =>
10      q.budget = 8.00
11      q.text = "Which one of these does not belong?"
12      q.options = List(
13        a.Option('oscar, "Oscar the Grouch"),
14        a.Option('kermit, "Kermit the Frog"),
15        a.Option('spongebob, "Spongebob Squarepants"),
16        a.Option('cookie, "Cookie Monster"),
17        a.Option('count, "The Count")
18      )
19    }
20
21    println("The answer is " + which_one())
22  }

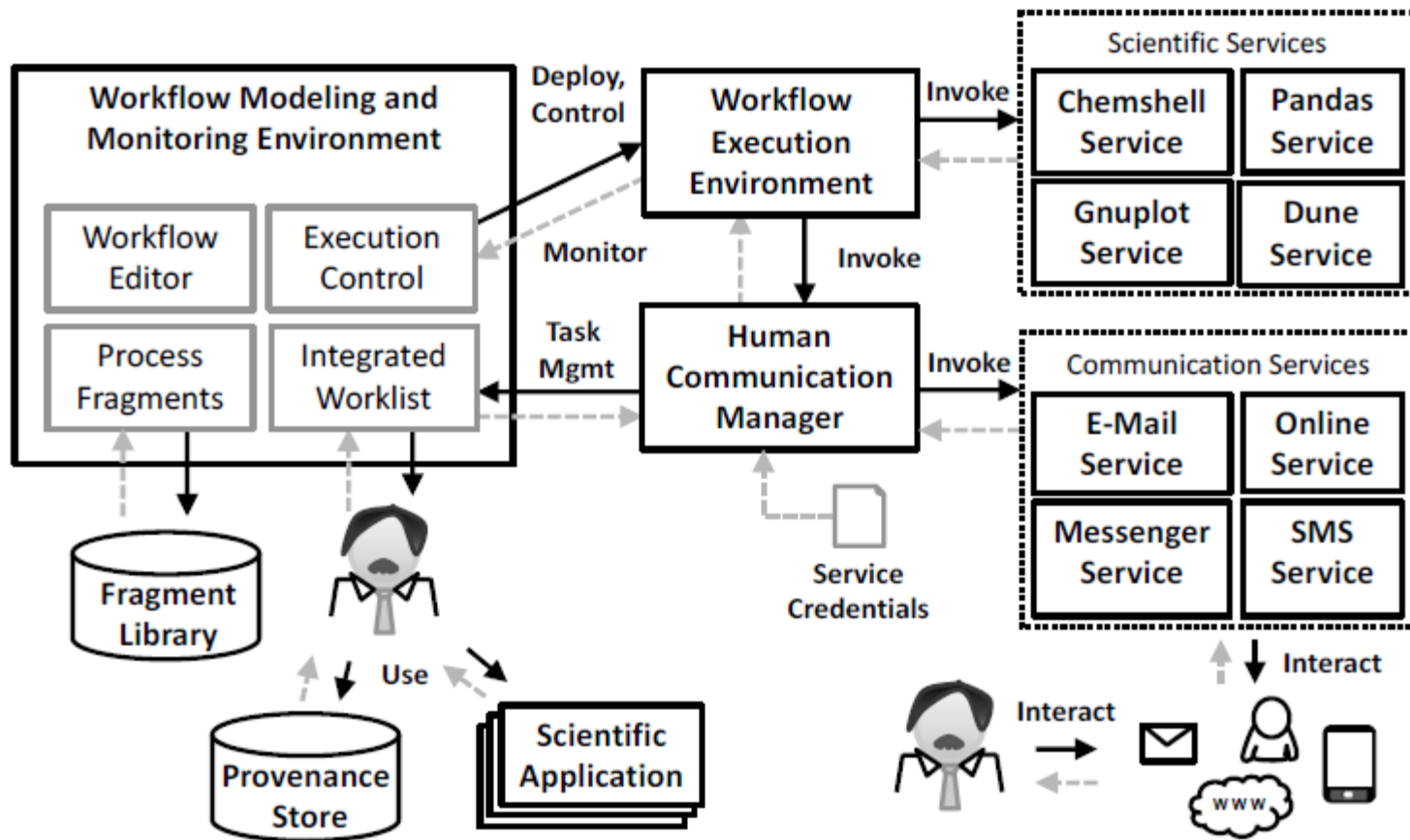
```



The screenshot shows the Amazon Mechanical Turk homepage. At the top, there's a navigation bar with links for 'Your Account', 'HITS', and 'Qualifications'. Below this, a yellow banner states 'Mechanical Turk is a marketplace for work.' and mentions '112,613 HITS available'. The main content area is divided into two columns. The left column, titled 'Make Money by working on HITS', describes the process for workers: 'Find an interesting task' (with a 'Find HITS Now' button), 'Work' (represented by a gear icon), and 'Earn money' (represented by a dollar sign icon). The right column, titled 'Get Results from Mechanical Turk Workers', describes the process for requesters: 'Fund your account' (with a 'Get Started' button), 'Load your tasks' (represented by a folder icon), and 'Get results' (represented by a star icon).

Source: Daniel W. Barowy, Charlie Curtsinger, Emery D. Berger, Andrew McGregor: **AutoMan: a platform for integrating human-based and digital computation.** OOPSLA 2012: 639-654

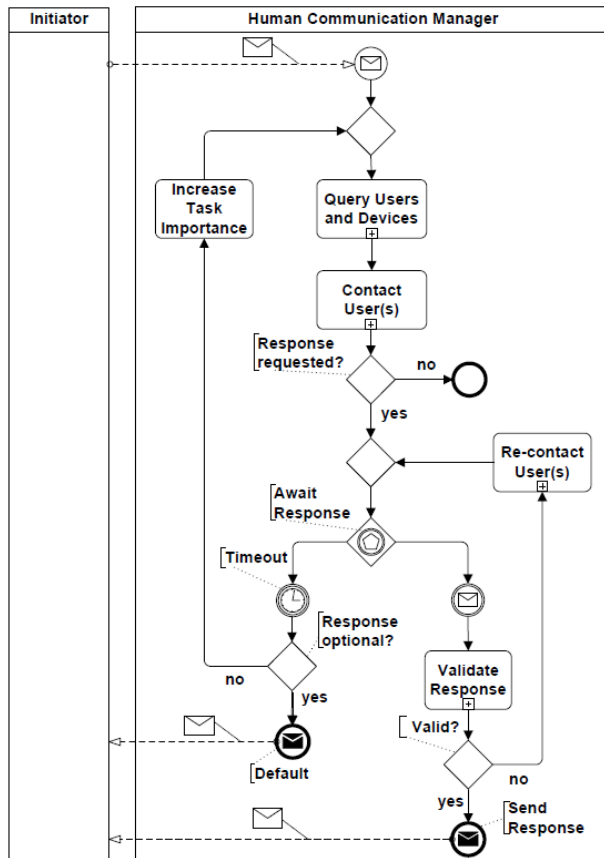
# SW4H approach (1)



Karastoyanova, Dimka; Dentsas, Dimitrios; Schumm, David; Sonntag, Mirko; Sun, Lina; Vukojevic, Karolina: Service-based Integration of Human Users in Workflow-driven Scientific Experiments. In: Proceedings of the 8th IEEE International Conference on eScience (eScience 2012)



# SW4H approach (2)



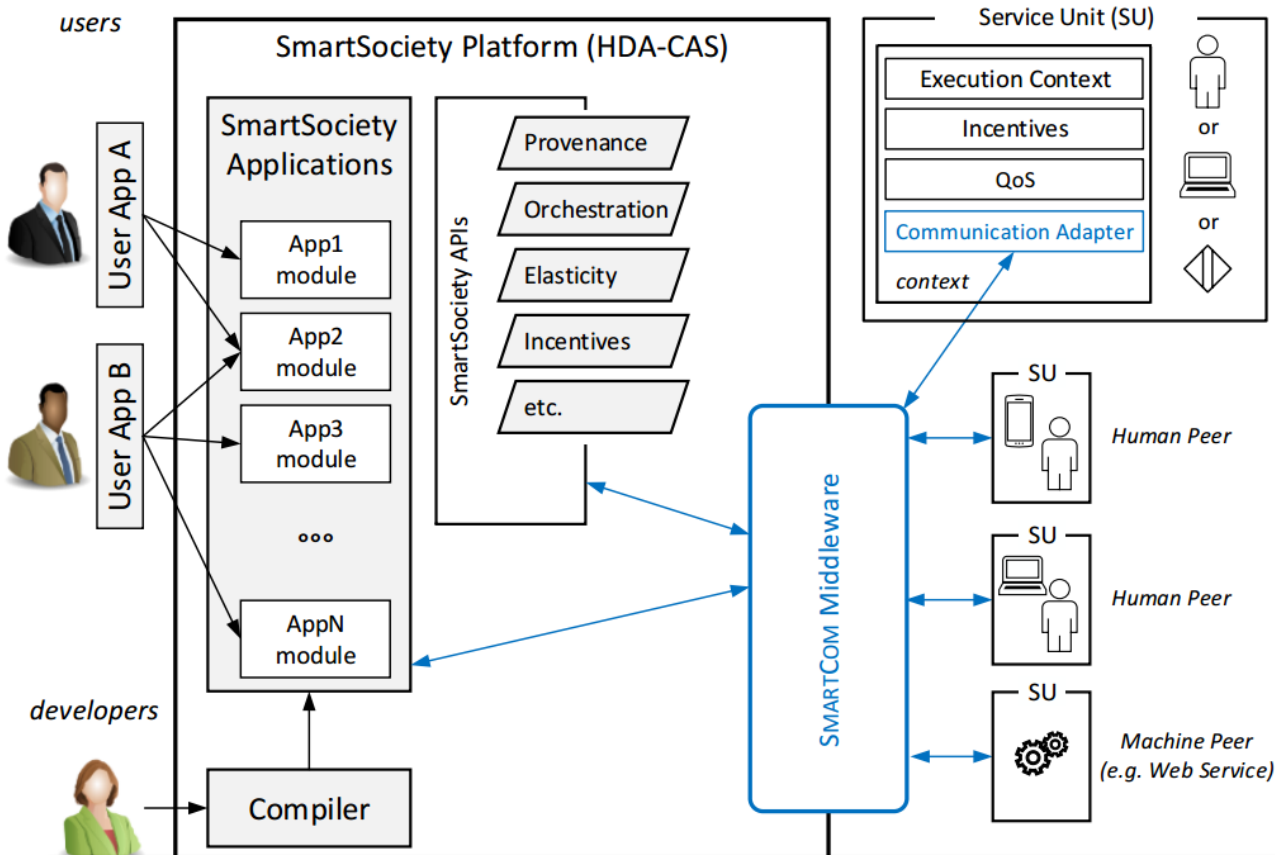
- Similar concepts in collaborative working environments but integrated into workflows
- Do not discuss about where and how to select human units

Karastoyanova, Dimka; Dentsas, Dimitrios; Schumm, David; Sonntag, Mirko; Sun, Lina; Vukojevic, Karolina: Service-based Integration of Human Users in Workflow-driven Scientific Experiments. In: Proceedings of the 8th IEEE International Conference on eScience (eScience 2012

# Viecom - Hybrid compute units

**Hybrid compute unit (HCU):** a set of service units includes software-based services, human-based services and things-based services *that can be provisioned, deployed and utilized as a collective* on-demand based on different quality, pricing and incentive models.

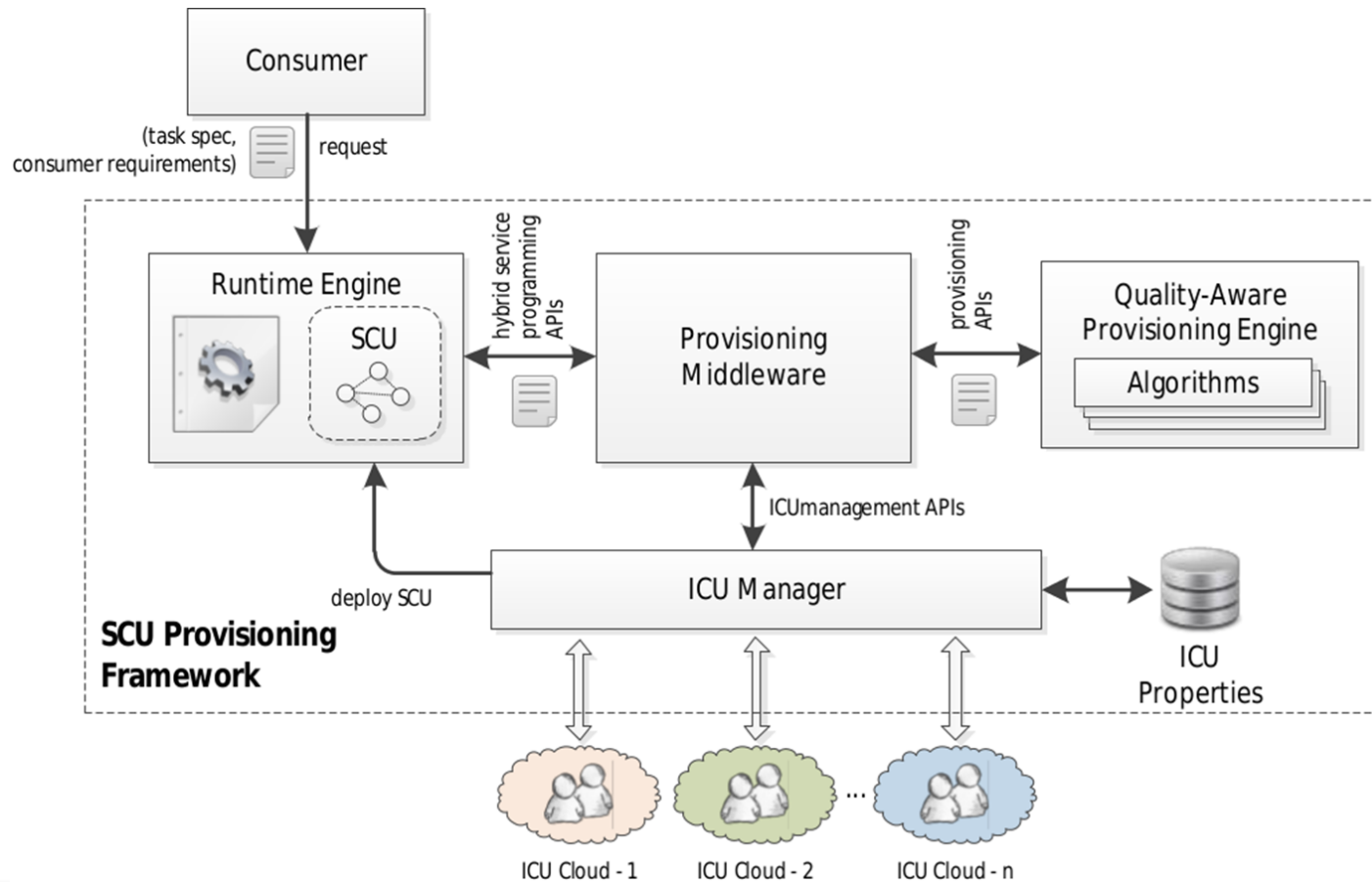
# TU WIEN VIECOM Highlights: Virtualizing Communication



- Extensible architecture
  - Adapters for: email, Dropbox, REST, Android
- Open source and documentation:
  - <https://github.com/tuwiendsg/SmartCom>

P. Zeppezauer, O. Scekcic, H.-L. Truong and S. Dustdar, "Virtualizing Communication for Hybrid and Diversity-Aware Collective Adaptive Systems," *10th International Workshop on Engineering Service-Oriented Applications (WESOA'14@ICSOC)*, Paris, 2014.

Zeppezauer, Virtualizing Communication for Hybrid and Diversity-aware Collective Adaptive Systems, Master thesis, Dec 2014.

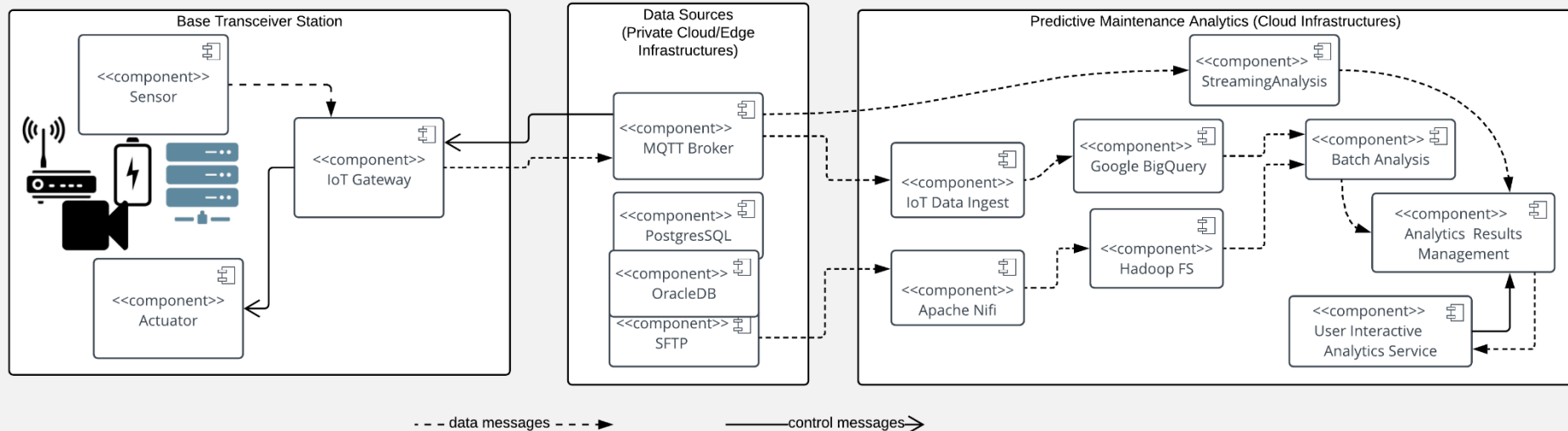


<https://github.com/tuwiendsg/RAHYMS>

Muhammad Z. C. Candra, Hong Linh Truong, Schahram Dustdar:

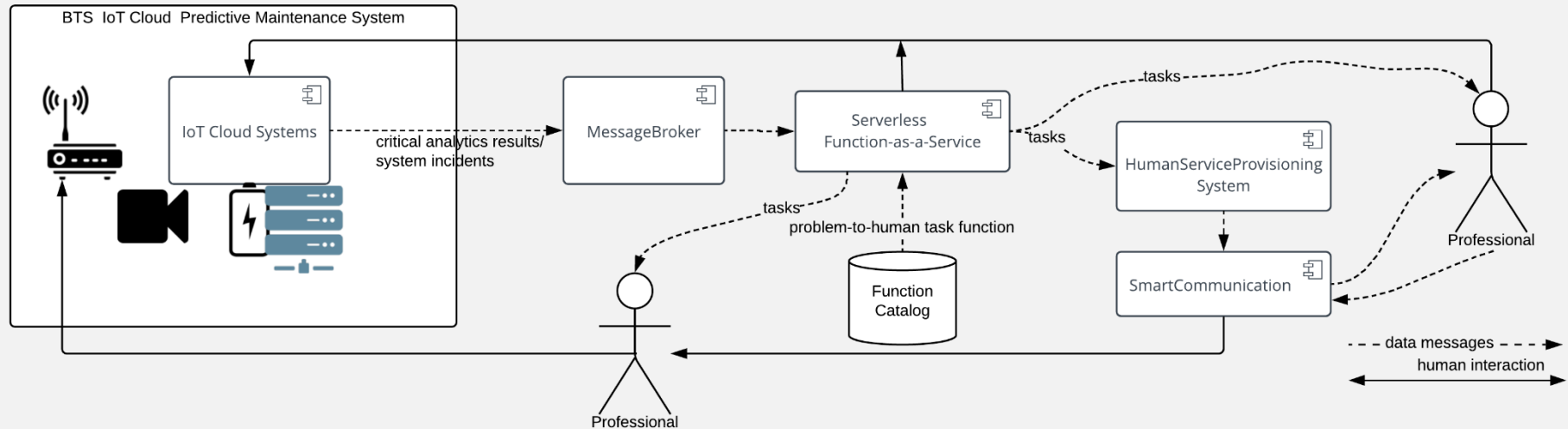
Provisioning Quality-Aware Social Compute Units in the Cloud. ICSOC 2013: 313-327

# IoT & Analytics for Predictive Maintenance Approach (INA4PM)



Predictive maintenance: incidents associated with equipment to be monitored and incidents associated with the big data systems

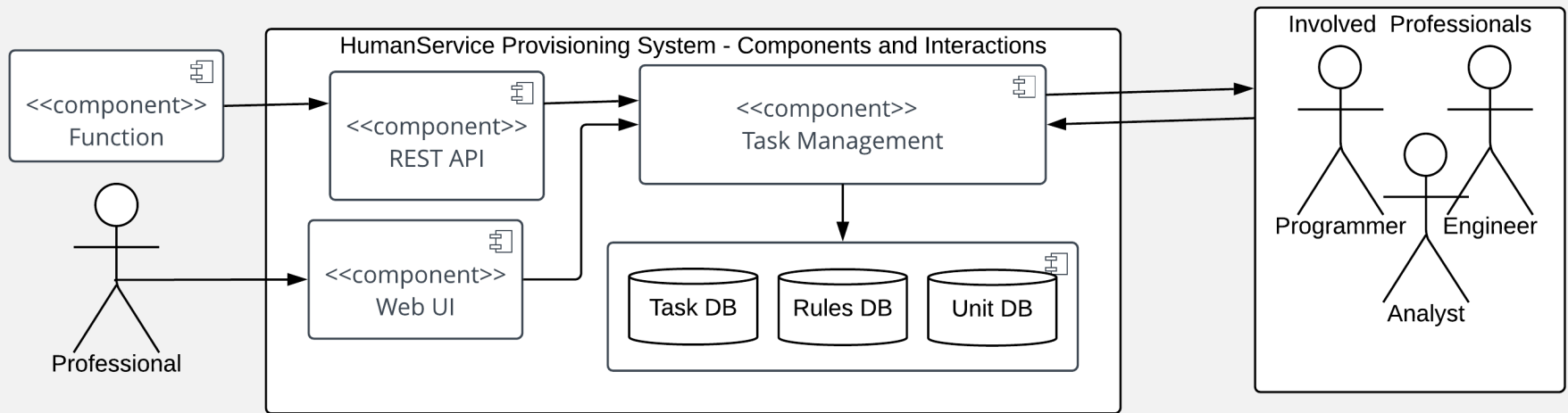
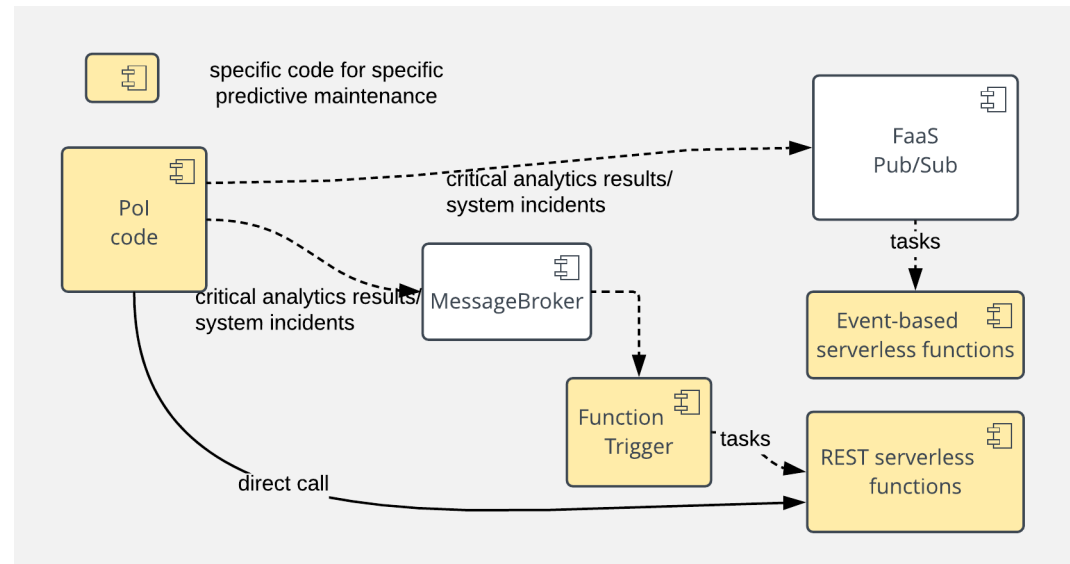
Hong-Linh Truong, Integrated Analytics for IIoT Predictive Maintenance using IoT Big Data Cloud Systems, On submission 2018.



## Where and when human units should be used?

Hong-Linh Truong, Integrated Analytics for IIoT Predictive Maintenance using IoT Big Data Cloud Systems, On submission 2018.

## How to invoke humans? Report incidents and generate human tasks



Hong-Linh Truong, Integrated Analytics for IIoT Predictive Maintenance using IoT Big Data Cloud Systems, On submission 2018.

# Alexa/Duplex



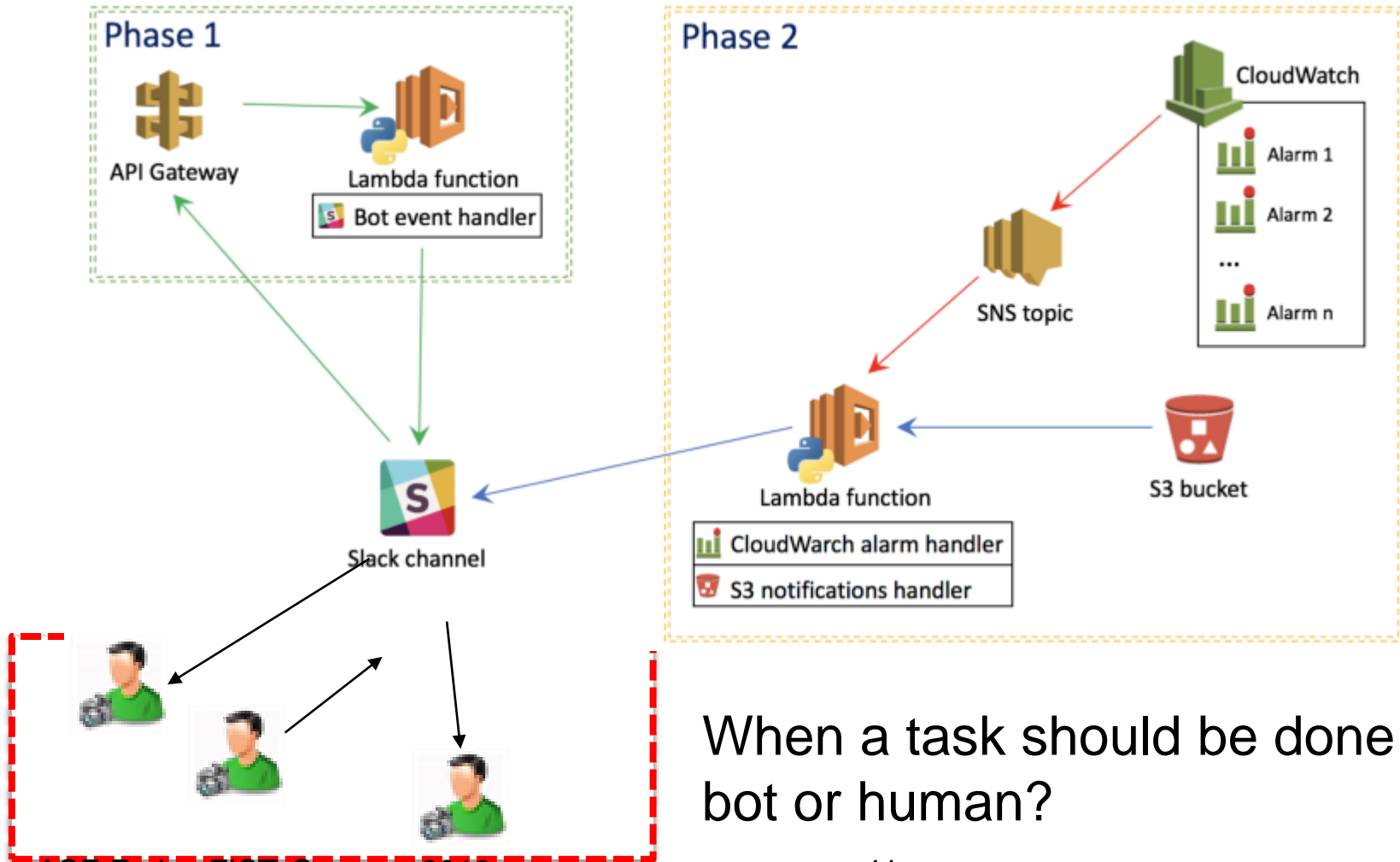
<https://ai.googleblog.com/2018/05/duplex-ai-system-for-natural-conversation.html>

- Voice (human)  $\leftarrow \rightarrow$  Voice (machine)  $\rightarrow$  Task (machine)
- Tasks  $\leftarrow \rightarrow$  Voice (machine)  $\leftarrow \rightarrow$  Voice (human)



# Human-Bot

Slack and Bot from Anton Chernysh, Source: <https://medium.com/devoops-and-universe/serverless-slack-bot-on-aws-vs-azure-getting-notified-instantly-ab0916393e1d>



When a task should be done by a bot or human?

# Eloquent: AI + Human Tasks

- <https://www.eloquent.ai/>
- Combine AI with humans for “task-oriented dialog AI”
- Which domains would it be good for?

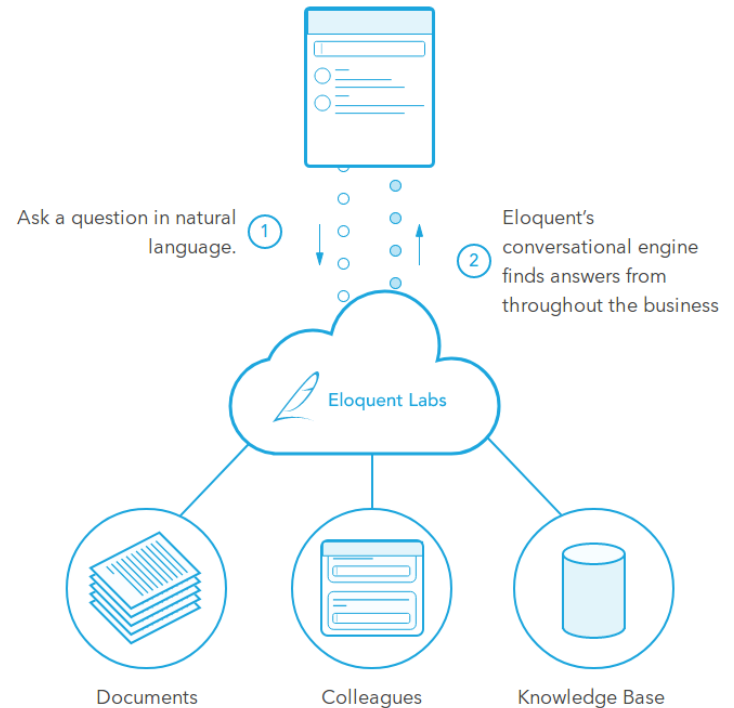


Figure source: <https://www.eloquent.ai/elk.html>

- Read mentioned papers
- Analyze pros and cons of existing frameworks for data analytics
- Survey existing algorithms for matching human units to data analytics tasks
- Examine requirements for locating places for human units and implement some algorithms
- Examine monitoring techniques for cloud of human compute units

# Thanks for your attention

Hong-Linh Truong  
Faculty of Informatics, TU Wien  
[hong-linh.truong@tuwien.ac.at](mailto:hong-linh.truong@tuwien.ac.at)  
<http://www.infosys.tuwien.ac.at/staff/truong@linhsolar>