Future Internet Apps: The Next Wave of Adaptive Service-Oriented Systems?

Andreas Metzger and Clarissa Cassales Marquezan

27th October, 2011

ServiceWave2011

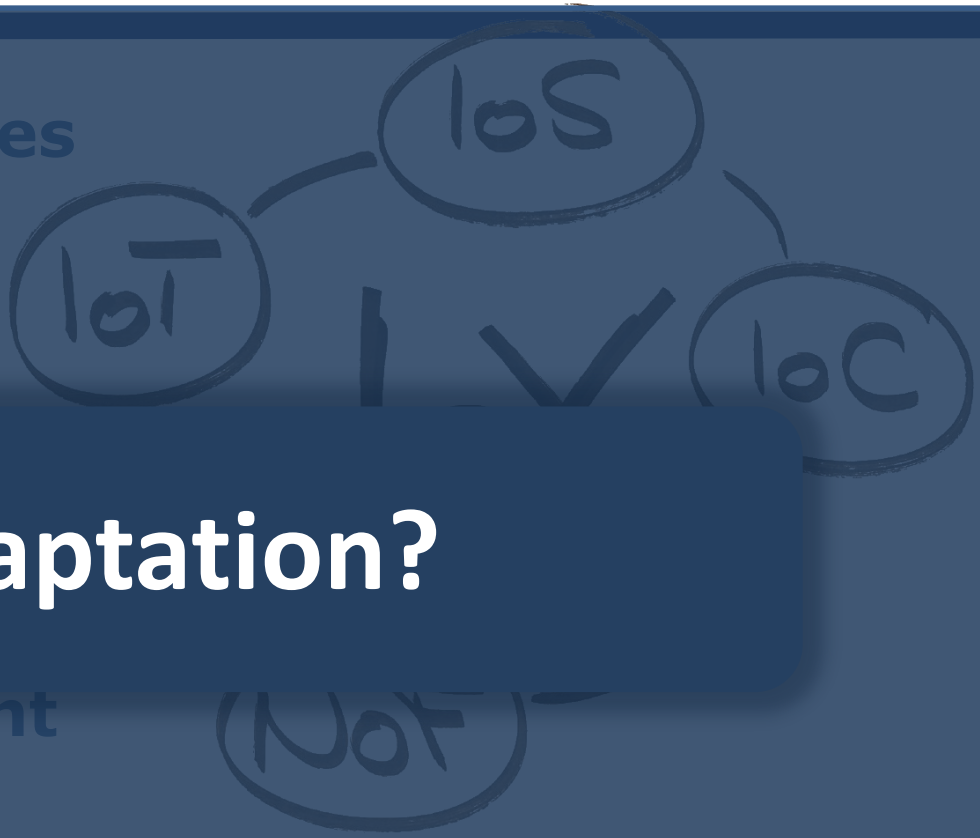
Poznan, Poland

Agenda

- Introduction
- Objectives
- Characteristics of Adaptive FIApps
- Assessment of Adaptive Characteristics Importance
- Conclusions

Future Internet Applications

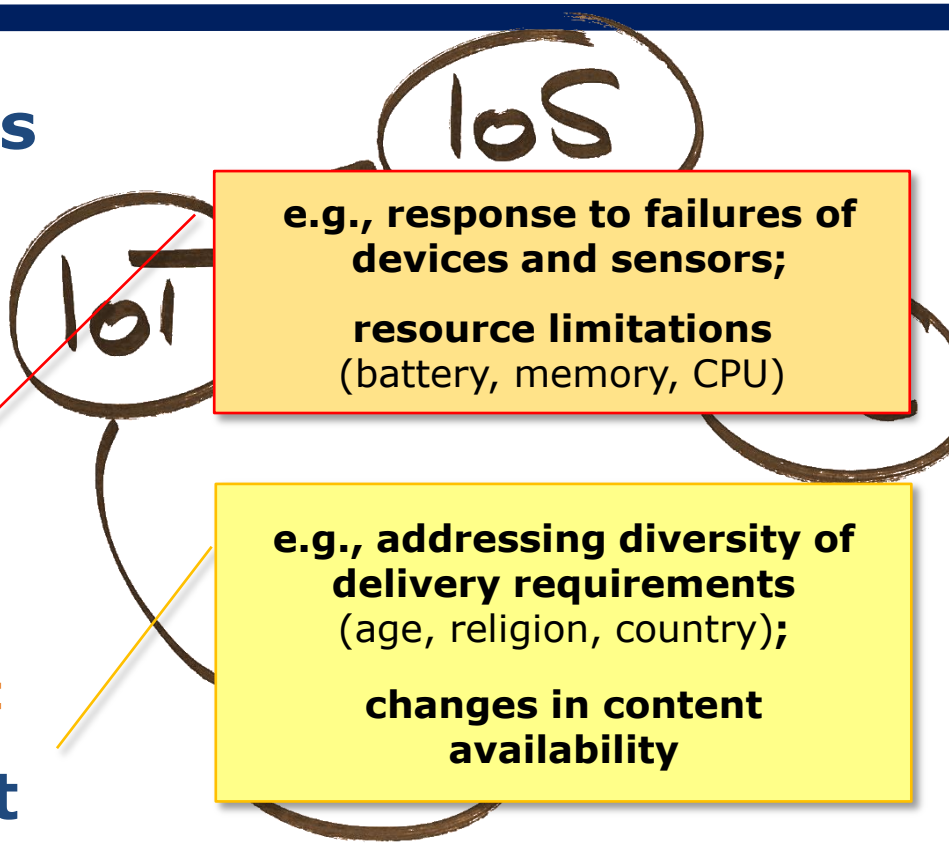
- IoS: Internet of Services
- Io
- IoC: Internet of Content
- NoF: Networks of the Future



Why adaptation?

Future Internet Applications - Why adaptation?

- **IoS: Internet of Services**
  - **3rd party services**
  - Changing **context & requirements**
- **IoT: Internet of Things**
  - **Connected** objects & **sensors**
  - Identification & **measurement**
- **IoC: Internet of Content**
  - Content **creation & delivery**
- **NoF: Networks of the Future**
  - **Ubiquitous** connectivity



e.g., response to failures of devices and sensors;

resource limitations (battery, memory, CPU)

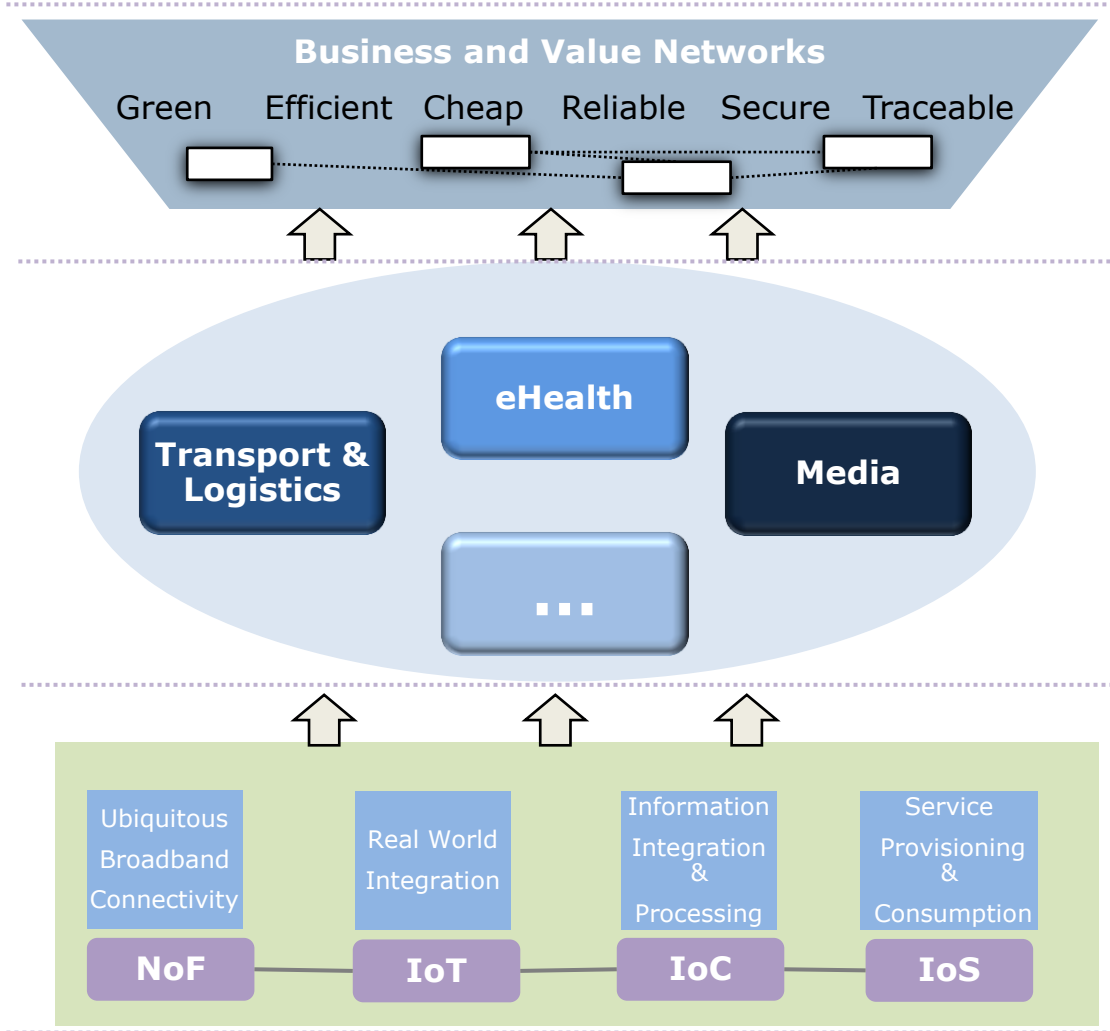
e.g., addressing diversity of delivery requirements (age, religion, country)**;**

changes in content availability

e.g., switching and routing between heterogeneous technologies (optical, wireless, sensor, satellite, etc.);

changes in bandwidth and quality of connectivity

FIApps: How?



[Source: FP7 project S-Cube, FI-ware, Dutch Freeband AWARENESS project]

Adaptive FIApps: How?

- Engineer FIApps with capabilities for dynamic and autonomous to changes on
  - Service provisioning
  - Availability of things and contents
  - Network connectivity

What are the adaptation capabilities to be considered in FIApps?

Objectives

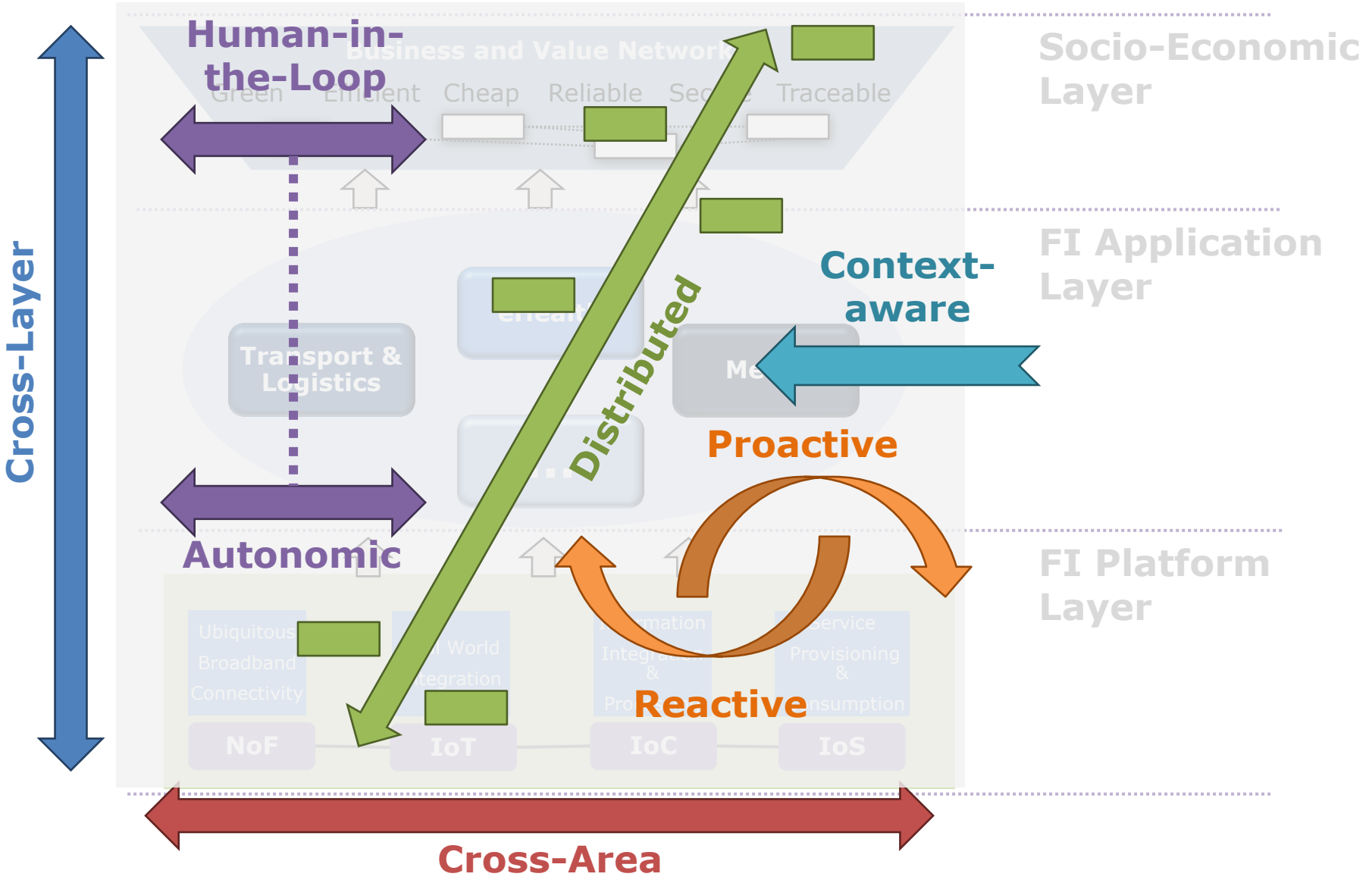
Characterize adaptation capabilities of FIApps

Assess the importance of characterized adaptation capabilities of FIApps

Agenda

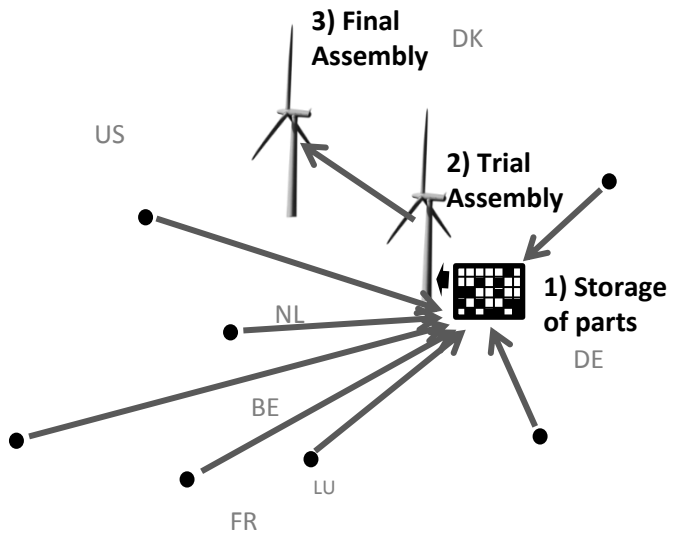
- Introduction
- Objectives
- **Characteristics of Adaptive FIApps**
  - **Transport and Logistics Use Case**
  - **Discussion about each identified characteristic**
- Assessment of Adaptive Characteristics Importance
- Conclusions

Characteristics of Adaptive FIApps



Transport & Logistics: Use Case

Off Shore Wind Engine Plant Construction
Current Transport and Logistics Process



● Supplier ⌨ System integrator

Steps

- Individual components produced by different suppliers
- OEM or system integrator receives the components
- OEM does trial assembly for full operational test
- Plant is disassembled and transported to final destination

Problems

- **Limited visibility** on T&L processes and critical events
- **Closed logistic supply chains** limits agile inter-organizational information exchange and collaboration
- **Highly manual processes**

Transport & Logistics: Use Case

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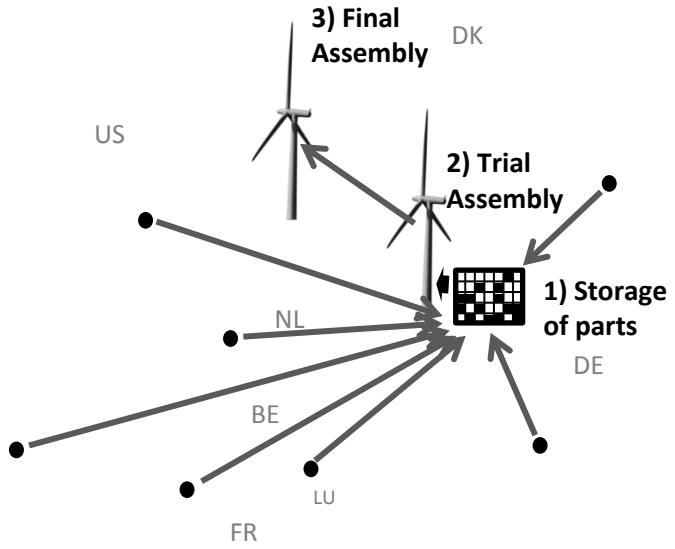
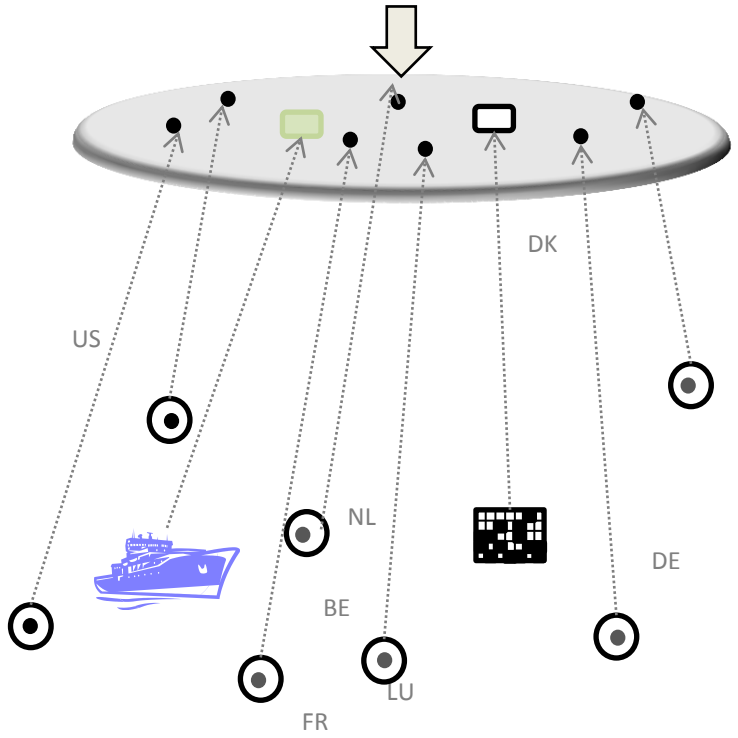


● Supplier

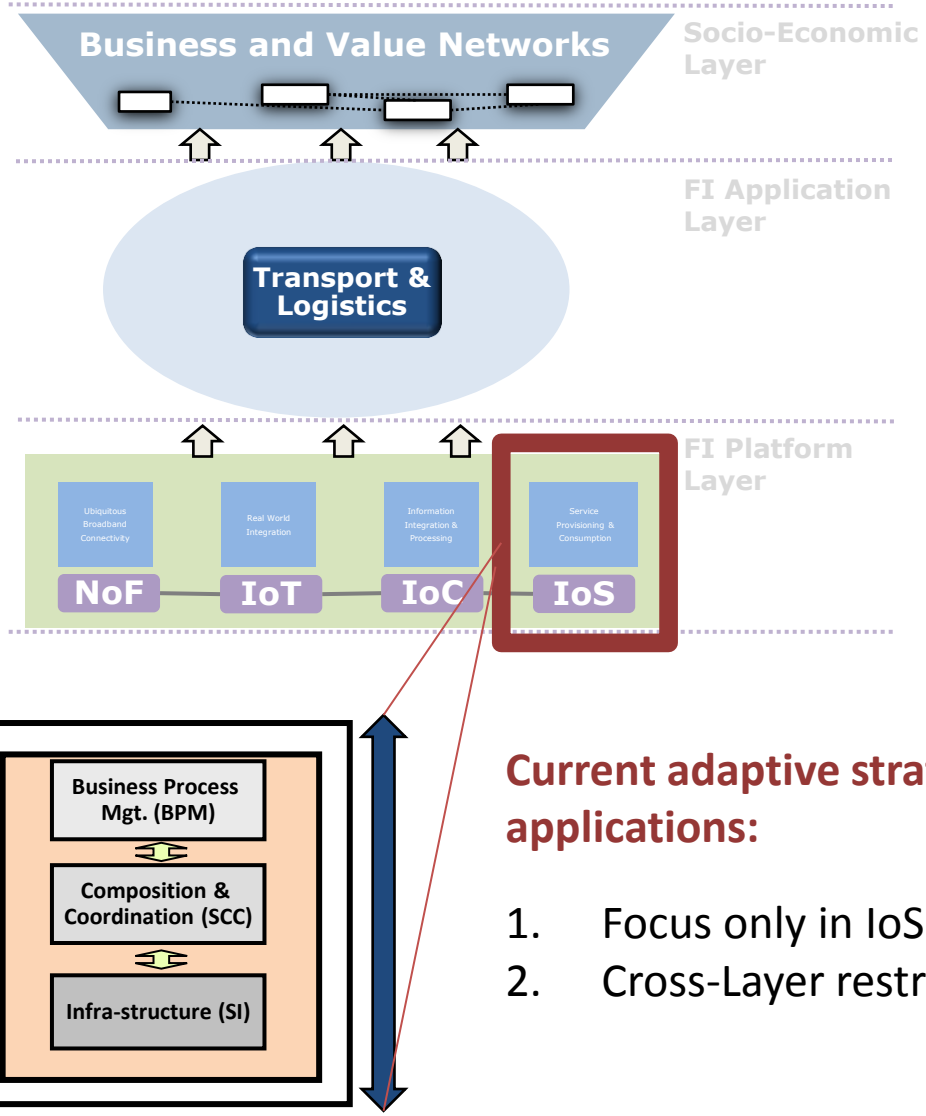
System integrator

T&L execution based on Future Internet Applications

NoF | IoT | IoC | IoS



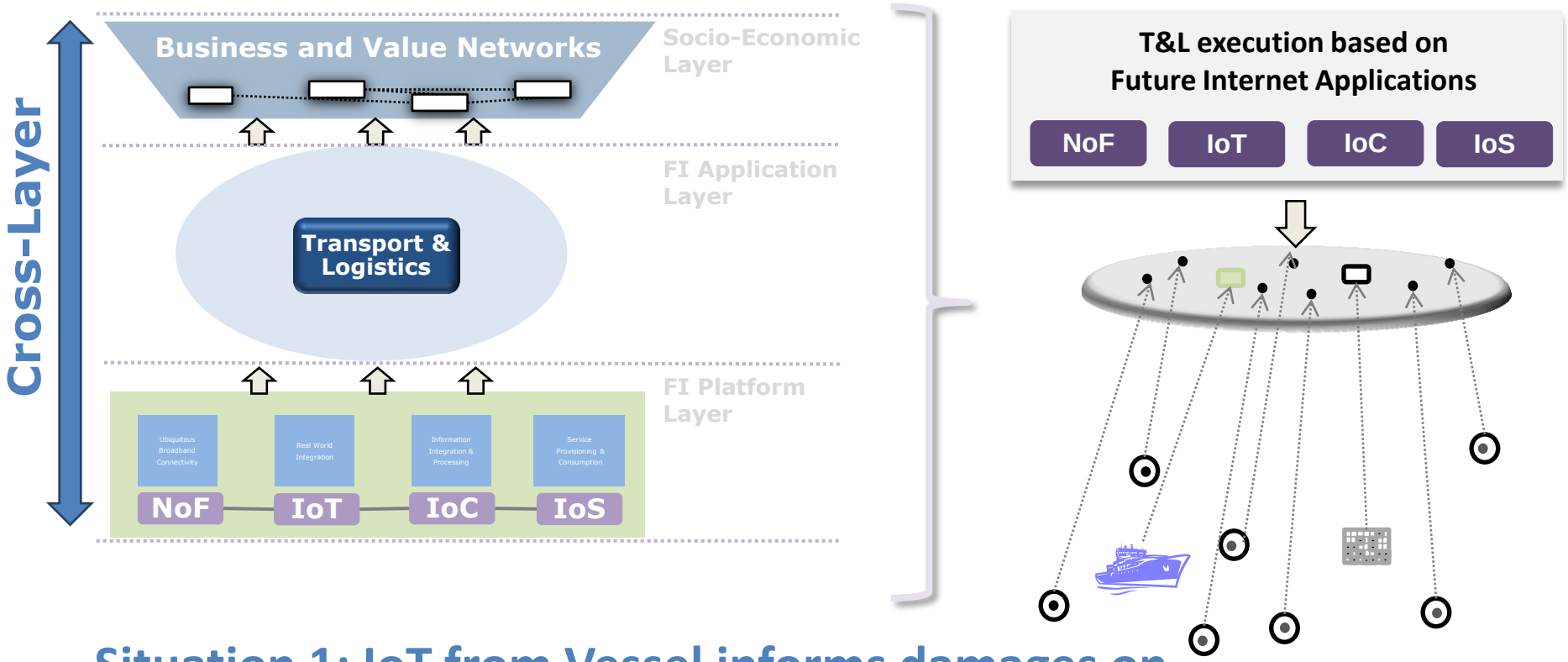
Cross-Layer Adaptation



Current adaptive strategies in Service-based applications:

1. Focus only in IoS area
2. Cross-Layer restrict to service technologies layers

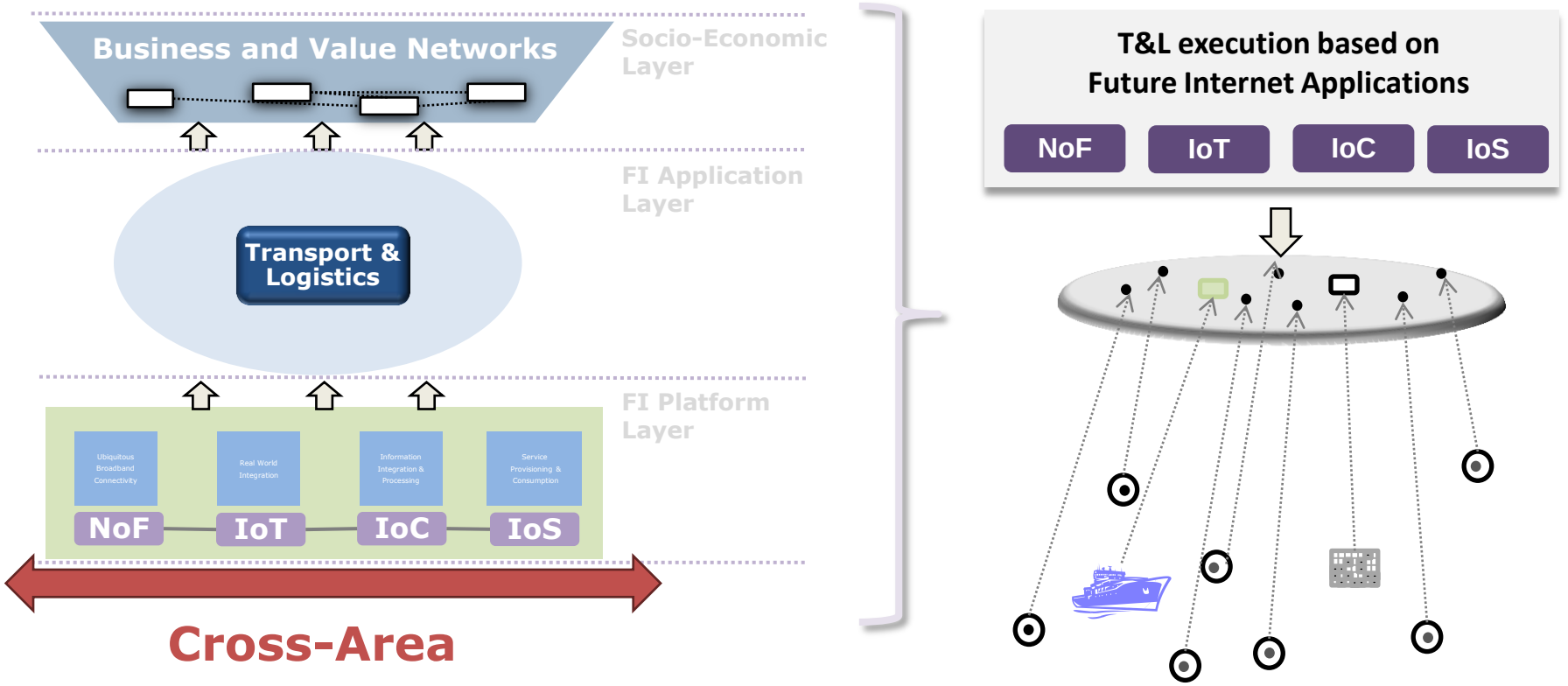
Cross-Layer Adaptation



Situation 1: IoT from Vessel informs damages on transported goods

- Cross-Layer on service technologies layers not enough
- Adaptation actions related to IoT up to the Socio-Economic Layer

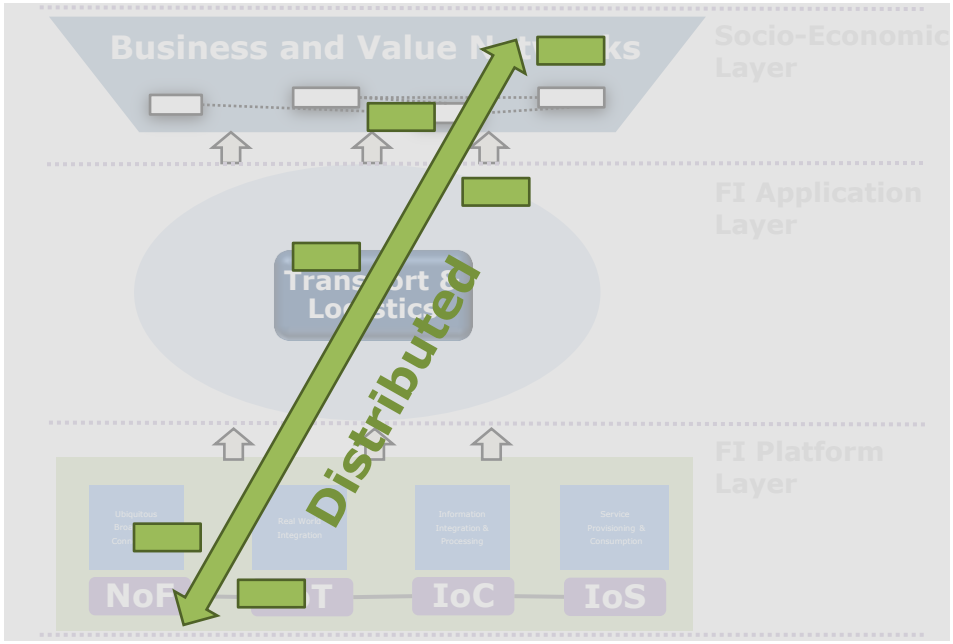
Cross-Area Adaptation

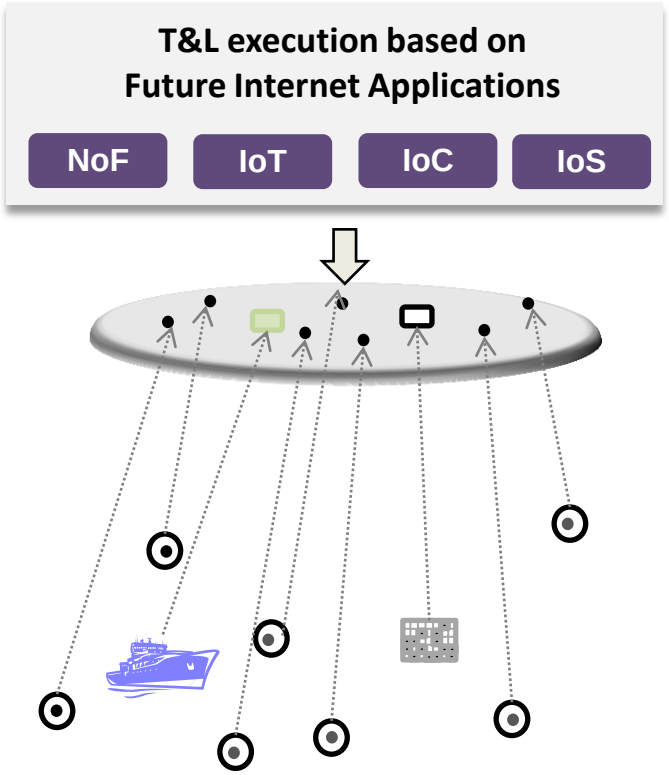


Situation 2: sensors from Vessel are damaged

- It is necessary to keep proving the information about the containers status
- Adaptation actions could change the source of information from sensors (IoT) to image from cameras on the Vessel (IoC)

Distributed Adaptation





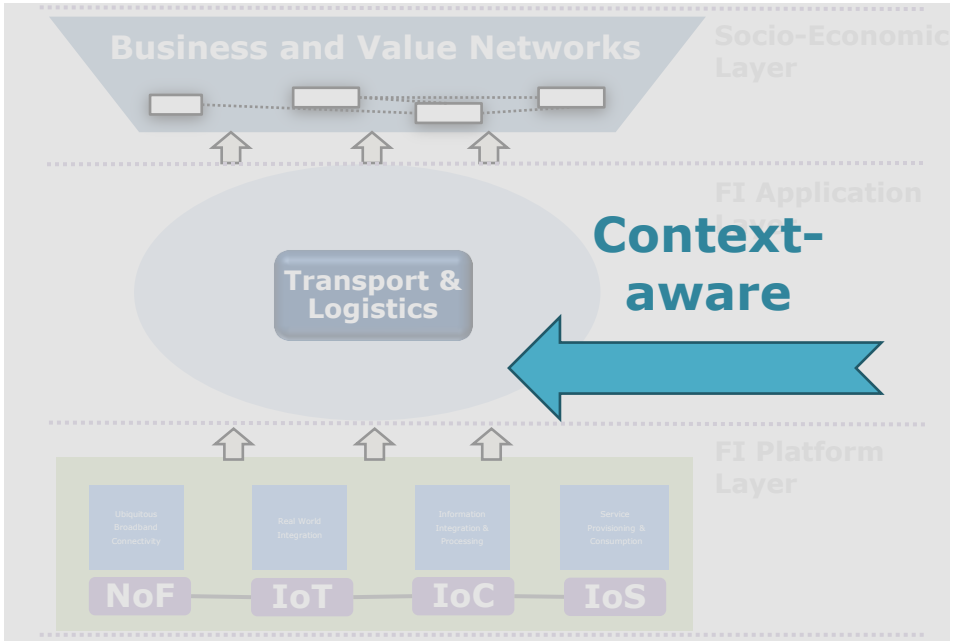
Situation 3a: gathering accurate information

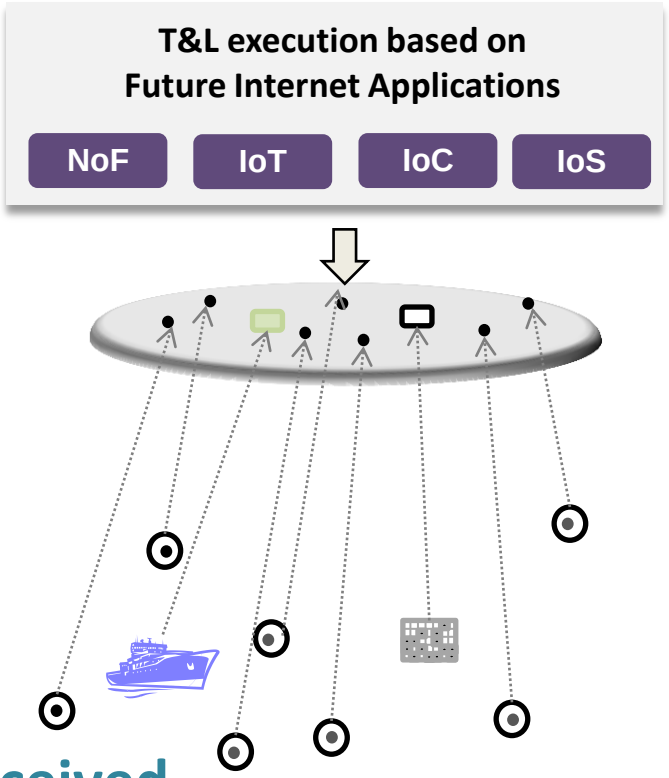
- Due to the scope, centralized monitoring to provide accurate information for the adaptation mechanism is not feasible

Situation 3b: need for recomposing services of supply chain

- Central entity cannot decide for all T&L partners, because it has no access to the parties business and infrastructure information

Context-Aware Adaptation

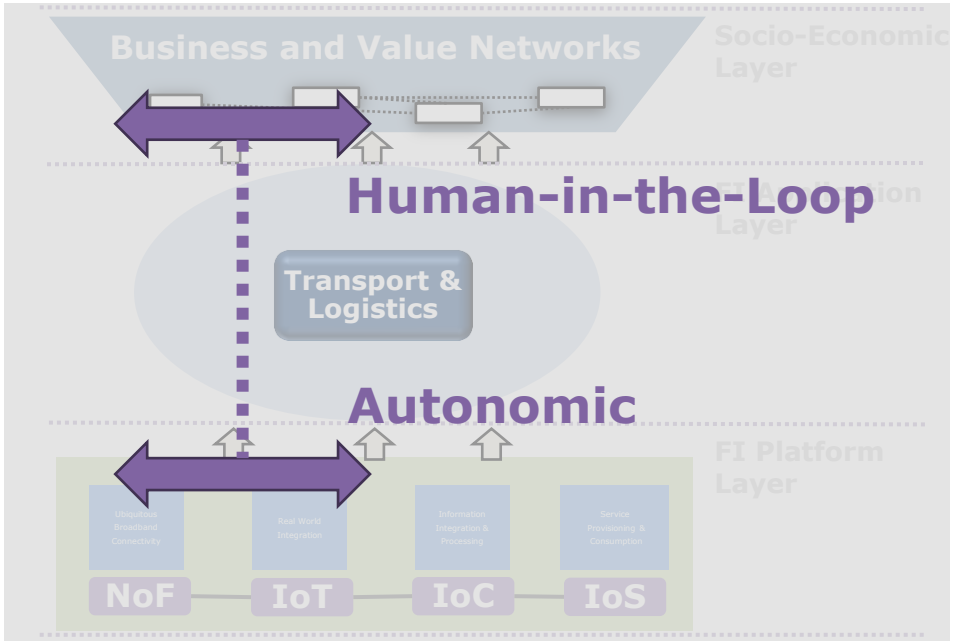


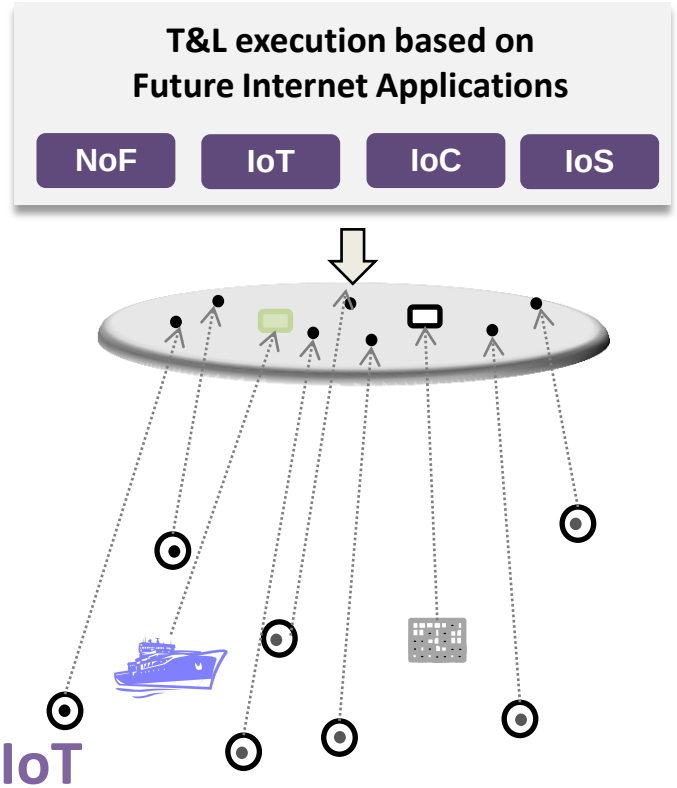


Situation 4: No Information from Vessel is received

- The supply chain should not start adaptation actions before check context of the Vessel
- Check network connectivity and weather forecasts

Autonomic and Human-in-the-loop Adaptation





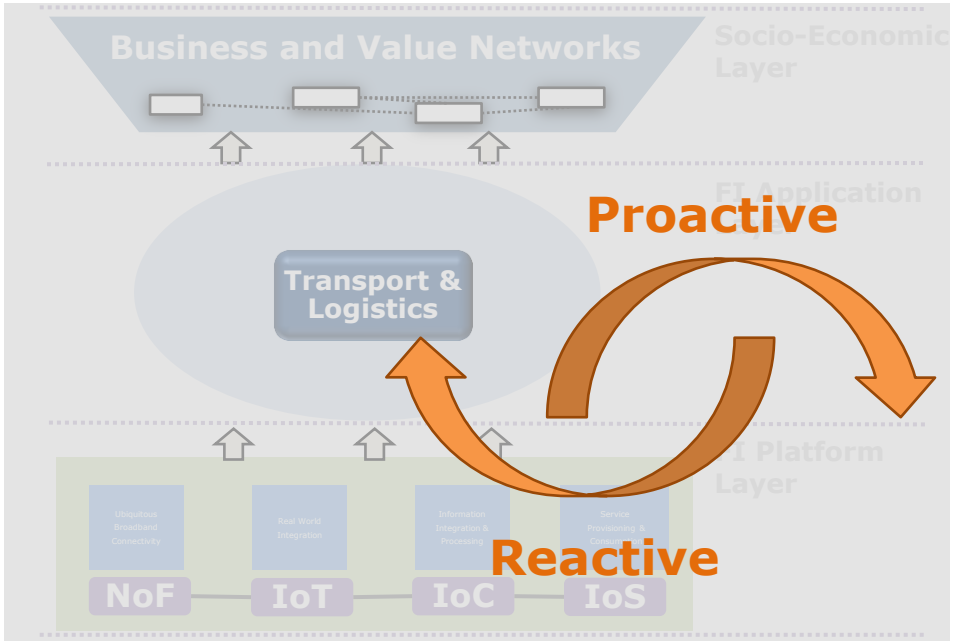
Situation 5a: How to decide to change from IoT information into IoC?

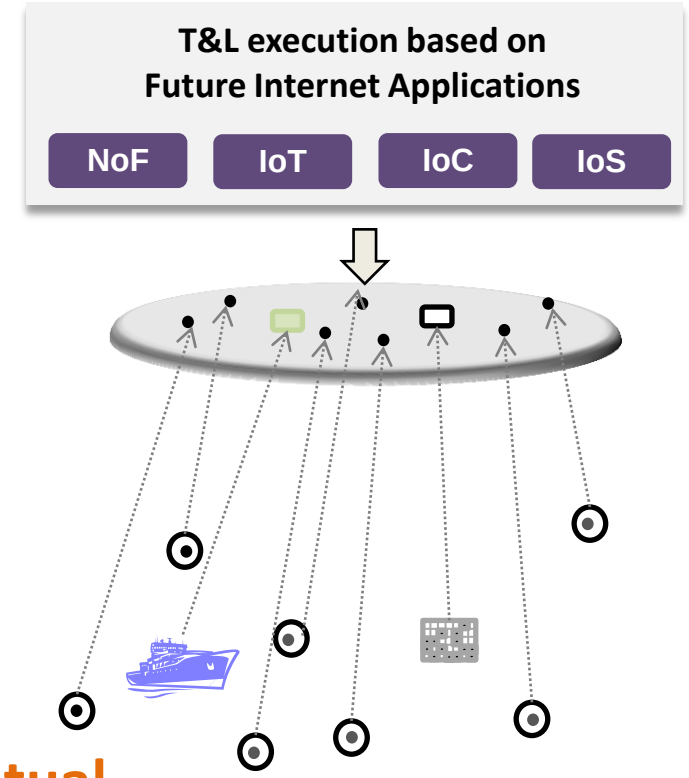
- Solely manual intervention might not scale.

Situation 5b: How to deal with re-contracting when the vessel is delayed?

- Solely autonomous decisions are not acceptable in the domain.

Reactive and Proactive Adaptation





Situation 7: Adapt supply chain in face eventual delays on the Vessel arrival

- Use weather forecast to predict deviations on the execution of the T&L process
- Proactively increase warehousing or change the transport mode

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Survey Study

- **Objective is to assess:**
  - Importance of different characteristics of FIApps
  - Importance of adaptation for layers, areas, and domains

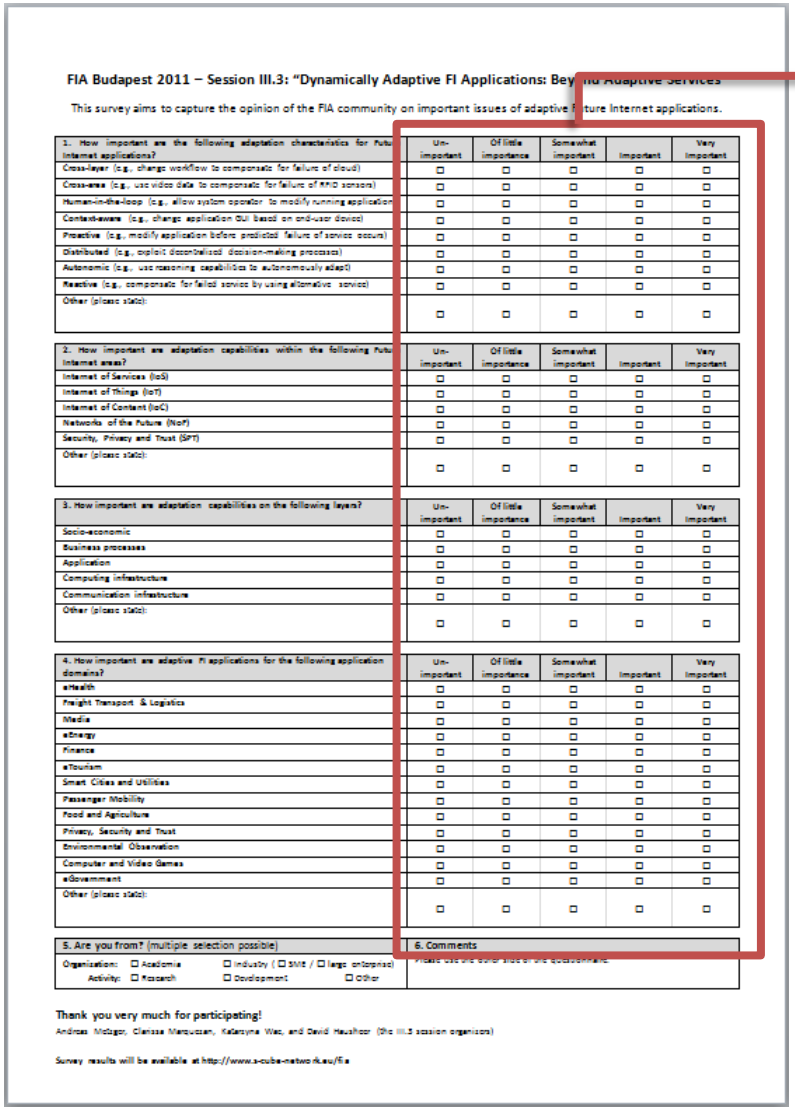
- **Context**
  - 6th Future Internet Assembly – Budapest 2011

    http://www.fi-budapest.eu/
    - Session SIII.3 - Dynamically Adaptive FI-Applications: Beyond Adaptive Services
  - Forum composed of international practitioners, academics, and policy makers (38% of response rate)

Population (% of TOTAL)	Academia	Industry	Other	TOTAL
Registered Participants	26 (51%)	24 (47%)	1 (2%)	51
Survey Respondents	10 (53%)	8 (42%)	1 (3%)	19

Survey Study

- Questionnaire (4 Questions)



FIA Budapest 2011 – Session III.3: "Dynamically Adaptive FI Applications: Bey[illegible] Adaptive Services"

This survey aims to capture the opinion of the FIA community on important issues of adaptive [illegible]ture Internet applications.

1. How important are the following adaptation characteristics for Futu Internet applications?	Un-important	Of little importance	Somewhat important	Important	Very important
Cross-layer (e.g., change workflow to compensate for failure of cloud)	☐	☐	☐	☐	☐
Cross-area (e.g., use video data to compensate for failure of RFID sensors)	☐	☐	☐	☐	☐
Human-in-the-loop (e.g., allow system operator to modify running application	☐	☐	☐	☐	☐
Context-aware (e.g., change application GUI based on end-user device)	☐	☐	☐	☐	☐
Proactive (e.g., modify application before predicted failure of service occurs)	☐	☐	☐	☐	☐
Distributed (e.g., exploit decentralized decision-making processes)	☐	☐	☐	☐	☐
Autonomic (e.g., use reasoning capabilities to autonomously adapt)	☐	☐	☐	☐	☐
Reactive (e.g., compensate for failed service by using alternative service)	☐	☐	☐	☐	☐
Other (please state):	☐	☐	☐	☐	☐

2. How important are adaptation capabilities within the following Futu Internet areas?	Un-important	Of little importance	Somewhat important	Important	Very important
Internet of Services (IoS)	☐	☐	☐	☐	☐
Internet of Things (IoT)	☐	☐	☐	☐	☐
Internet of Content (IoC)	☐	☐	☐	☐	☐
Networks of the Future (NoF)	☐	☐	☐	☐	☐
Security, Privacy and Trust (SPT)	☐	☐	☐	☐	☐
Other (please state):	☐	☐	☐	☐	☐

3. How important are adaptation capabilities on the following layers?	Un-important	Of little importance	Somewhat important	Important	Very important
Socio-economic	☐	☐	☐	☐	☐
Business processes	☐	☐	☐	☐	☐
Application	☐	☐	☐	☐	☐
Computing infrastructure	☐	☐	☐	☐	☐
Communication infrastructure	☐	☐	☐	☐	☐
Other (please state):	☐	☐	☐	☐	☐

4. How important are adaptive FI applications for the following application domains?	Un-important	Of little importance	Somewhat important	Important	Very important
eHealth	☐	☐	☐	☐	☐
Freight Transport & Logistics	☐	☐	☐	☐	☐
Media	☐	☐	☐	☐	☐
eEnergy	☐	☐	☐	☐	☐
Finance	☐	☐	☐	☐	☐
eTourism	☐	☐	☐	☐	☐
Smart Cities and Utilities	☐	☐	☐	☐	☐
Passenger Mobility	☐	☐	☐	☐	☐
Food and Agriculture	☐	☐	☐	☐	☐
Privacy, Security and Trust	☐	☐	☐	☐	☐
Environmental Observation	☐	☐	☐	☐	☐
Computer and Video Games	☐	☐	☐	☐	☐
eGovernment	☐	☐	☐	☐	☐
Other (please state):	☐	☐	☐	☐	☐

5. Are you from? (multiple selection possible)	6. Comments
Organization: ☐ Academia ☐ Industry (☐ SME / ☐ large enterprise) Activity: ☐ Research ☐ Development ☐ Other	Please use the other side of the questionnaire.

Thank you very much for participating!

Andreas Metzger, Clarissa Marquezan, Katarzyna Wac, and David Hausheer (the III.3 session organizers)

Survey results will be available at http://www.s-cube-network.eu/fia

Respondents have to rate each option of each question

Un-important	Of little importance	Somewhat important	Important	Very Important
☐	☐	☐	☐	☐
☐	☐	☐	☐	☐
☐	☐	☐	☐	☐
☐	☐	☐	☐	☐
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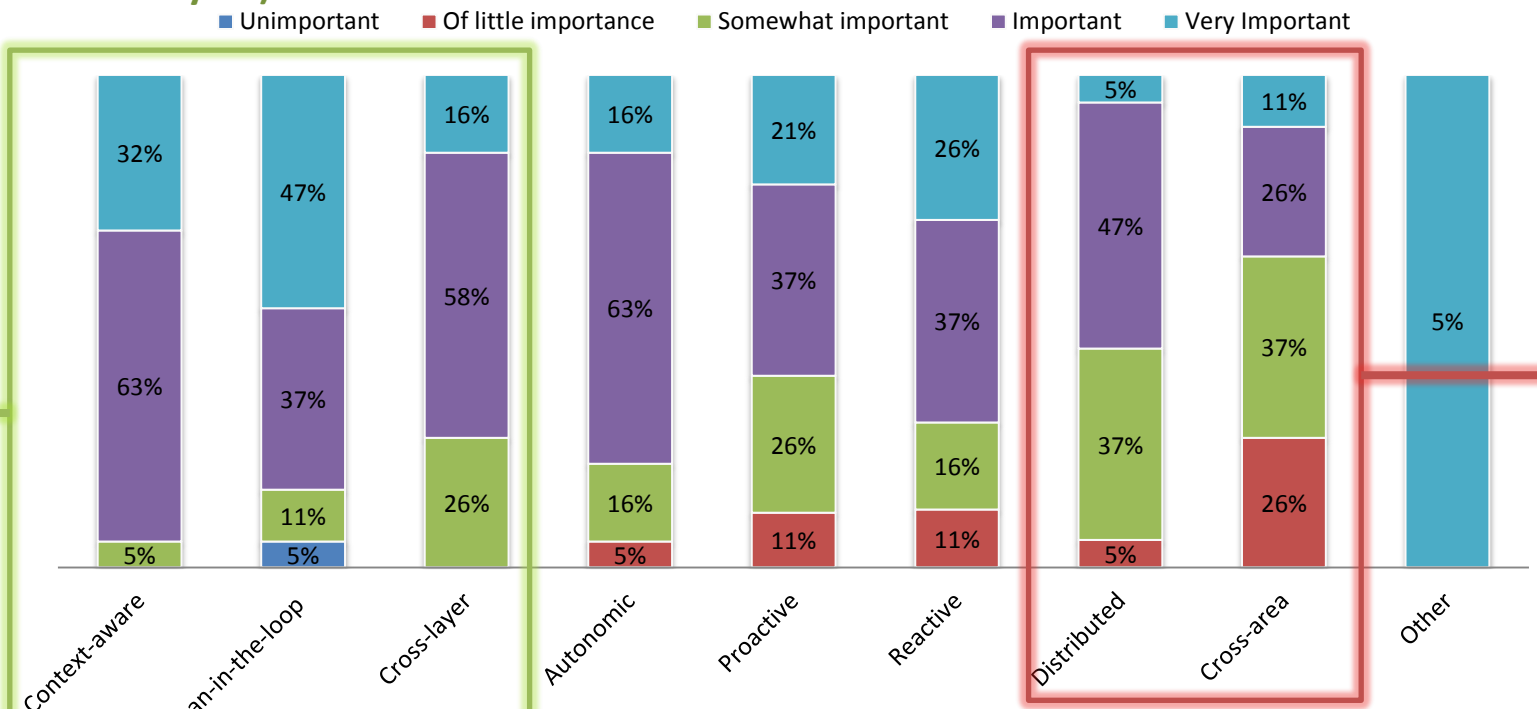
☐	☐	☐	☐	☐
☐	☐	☐	☐	☐

Analysis Q1

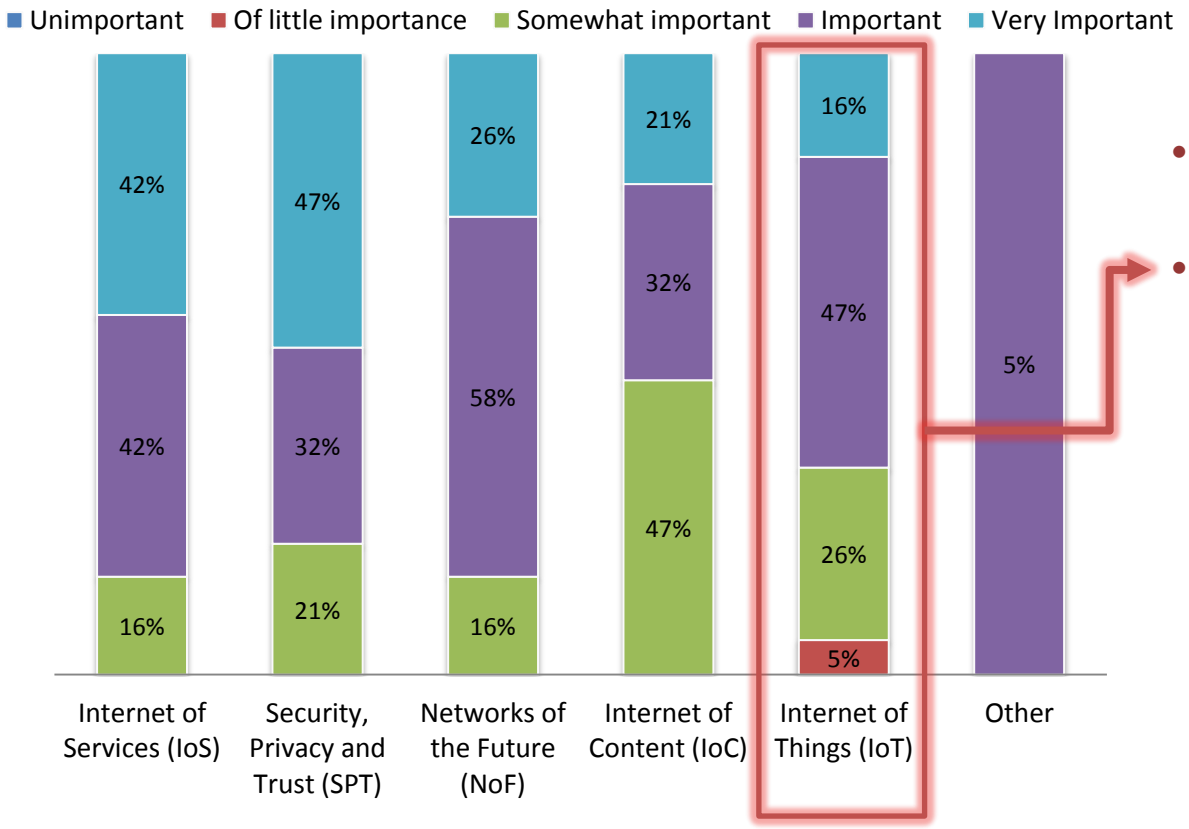
- How important are the following adaptation characteristics for Future Internet Applications?
  - **Indicates the need to better understand the role of users (Context-aware associated usage factors; Cross-layer associated with business and socio-economic layers)**



- **Literature points to distributed SOS**
- **FI areas not established**

Analysis Q2

- Q2: How important are adaptation capabilities within the following Future Internet areas?

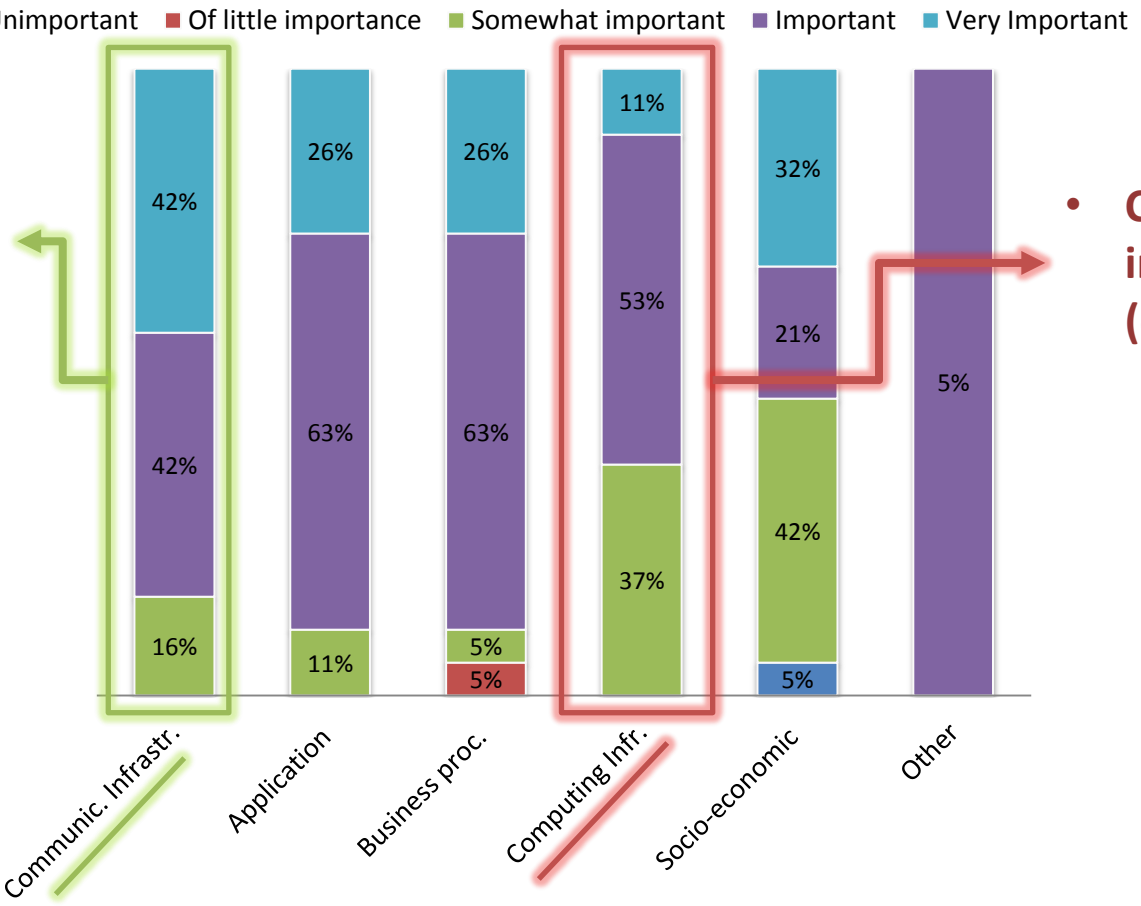


- **Adaptation of IoT is less important**
- **IoT perceived so far as static environment**

Analysis Q3

- Q3: How important are adaptation capabilities for the following layers?

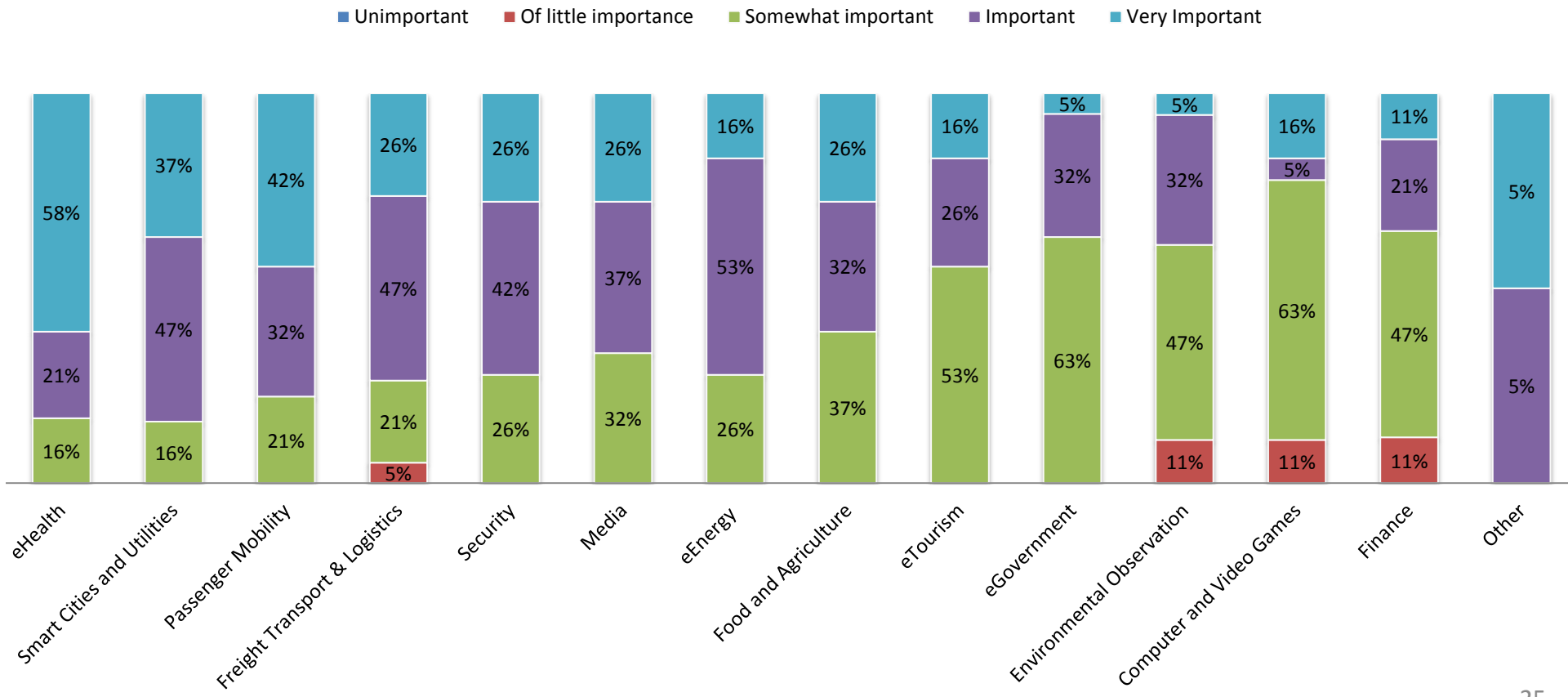
- **Could indicate contradiction (adaptation is more important for IoS in Q2)**
- **Adaptation in IoS is strongly related to communication infrastructure**



- **Computing infrastructure (e.g., Cloud)**

Analysis Q4

- How important are adaptive Future Internet Applications for the following domains?



Conclusions

- Engineering adaptive FIApps
  - Need to identify which adaptive characteristics are relevant for the target domain of the application
- Survey Study
  - Confirmed some expectations
    - Importance of adaptation for IoS
  - Presented unexpected results
    - Minor importance of cross-area and distributed adaptive characteristics
- Further investigations are necessary

Andreas Metzger and Clarissa Cassales Marquezan (clarissa.marquezan@paluno.uni-due.de)

27th October, 2011
ServiceWave2011
Poznan, Poland

THANK YOU!

Details of the Survey Design

- Based on psychological findings*
  - Raking time consuming
  - People prefer to rate
- Answers choices**
  - “No opinion” not used -> can compromise the data quality
  - Verbal scale labels
  - Five point scale started from negative to positive answers
- Pre test of questionnaire with 10 respondents

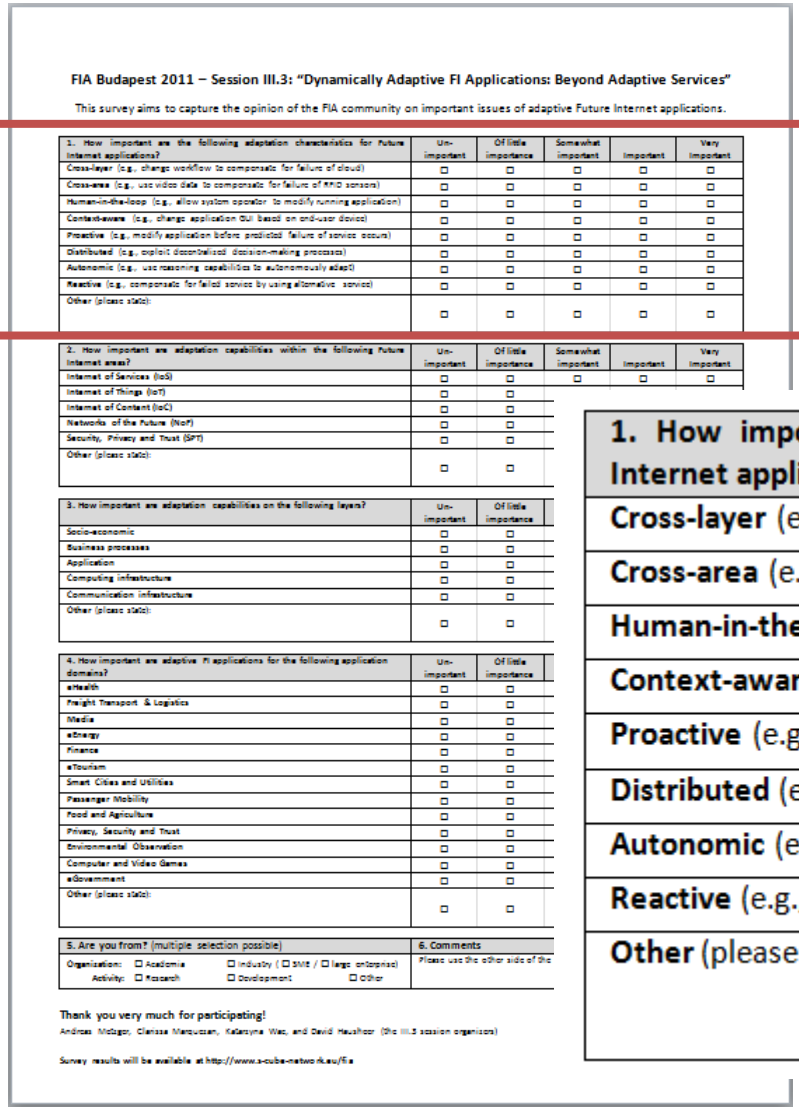
* Krosnick, J.: Survey research. Annual review of psychology 50(1), 537{567 (1999)
** Narasimhan, B., Nichols, R.: State of cloud applications and platforms: The cloud adopters' view. IEEE Computer 44(3), 24{28 (2011)

Threats to Validity

- Construct validity
  - Addressed by the design choices and pre test
- Internal validity
  - Careful interpretation of results on Q4 related to eHealth, Media and T&L
  - Dedicated presentations about those topics
- External Validity
  - Demographic distribution of respondents x registered participants
  - Participants were not randomly chosen
    - Careful generalization of results

Survey Study

- Questionnaire



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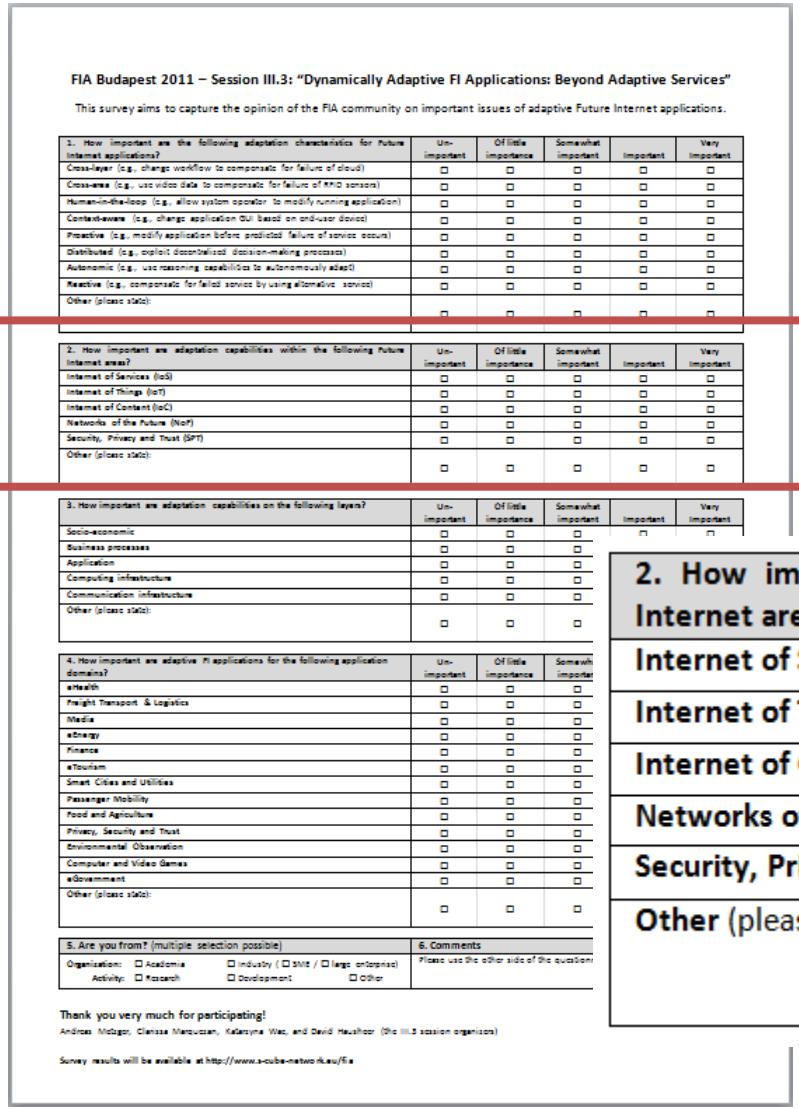
Survey Study

- Questionnaire



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Internet of Things (IoT)	☐	☐	☐	☐	☐
Internet of Content (IoC)	☐	☐	☐	☐	☐
Networks of the Future (NoF)	☐	☐	☐	☐	☐
Security, Privacy and Trust (SPT)	☐	☐	☐	☐	☐
Other (please state):	☐	☐	☐	☐	☐

3. How important are adaptation capabilities on the following layers?	Un-important	Of little importance	Somewhat important	Important	Very important
Socio-economic	☐	☐	☐		
Business processes	☐	☐	☐		
Application	☐	☐	☐		
Computing infrastructure	☐	☐	☐		
Communication infrastructure	☐	☐	☐		
Other (please state):	☐	☐	☐		

4. How important are adaptive FI applications for the following application domains?	Un-important	Of little importance	Somewh
eHealth	☐	☐	☐
Freight Transport & Logistics	☐	☐	☐
Media	☐	☐	☐
eEnergy	☐	☐	☐
Finance	☐	☐	☐
eTourism	☐	☐	☐
Smart Cities and Utilities	☐	☐	☐
Passenger Mobility	☐	☐	☐
Food and Agriculture	☐	☐	☐
Privacy, Security and Trust	☐	☐	☐
Environmental Observation	☐	☐	☐
Computer and Video Games	☐	☐	☐
eGovernment	☐	☐	☐
Other (please state):	☐	☐	☐

5. Are you from? (multiple selection possible)	6. Comments
Organization: ☐ Academia ☐ Industry (☐ SME / ☐ large enterprise) Activity: ☐ Research ☐ Development ☐ Other	Please use the other side of the questionn

Thank you very much for participating!

Andreas McGgor, Clarissa Marquezan, Katarzyna Wac, and David Hausheer (the III.3 session organizers)

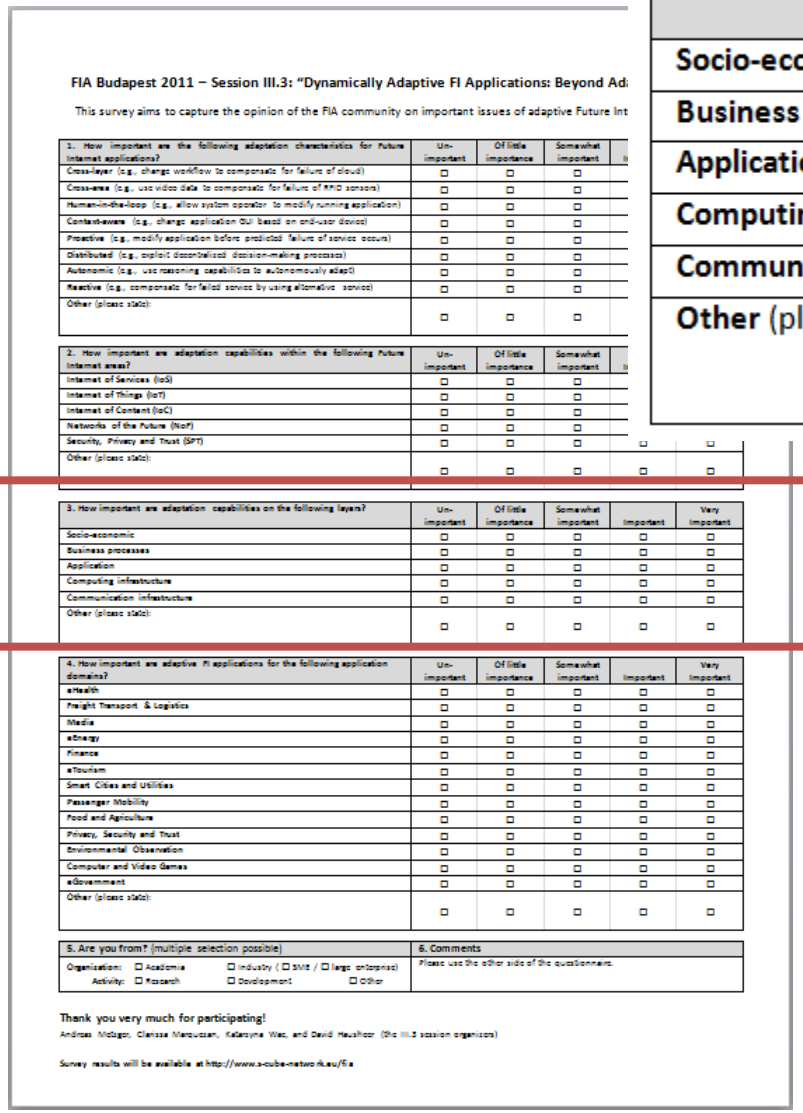
Survey results will be available at http://www.s-cube-network.eu/fia

Question 2 (Q2)

2. How important are adaptation capabilities within the following Future Internet areas?	
Internet of Services (IoS)	
Internet of Things (IoT)	
Internet of Content (IoC)	
Networks of the Future (NoF)	
Security, Privacy and Trust (SPT)	
Other (please state):	

Survey Study

- Questionnaire



FIA Budapest 2011 – Session III.3: "Dynamically Adaptive FI Applications: Beyond Ad

This survey aims to capture the opinion of the FIA community on important issues of adaptive Future Int

1. How important are the following adaptation characteristics for Future Internet applications?	Un-important	Of little importance	Somewhat important
Cross-layer (e.g., change workflow to compensate for failure of cloud)	☐	☐	☐
Cross-area (e.g., use video data to compensate for failure of RFID sensors)	☐	☐	☐
Human-in-the-loop (e.g., allow system operator to modify running application)	☐	☐	☐
Context-aware (e.g., change application GUI based on end-user device)	☐	☐	☐
Proactive (e.g., modify application before predicted failure of service occurs)	☐	☐	☐
Distributed (e.g., exploit decentralized decision-making processes)	☐	☐	☐
Autonomic (e.g., use reasoning capabilities to autonomously adapt)	☐	☐	☐
Reactive (e.g., compensate for failed service by using alternative service)	☐	☐	☐
Other (please state):	☐	☐	☐

2. How important are adaptation capabilities within the following Future Internet areas?	Un-important	Of little importance	Somewhat important
Internet of Services (IoS)	☐	☐	☐
Internet of Things (IoT)	☐	☐	☐
Internet of Content (IoC)	☐	☐	☐
Networks of the Future (NoF)	☐	☐	☐
Security, Privacy and Trust (SPT)	☐	☐	☐
Other (please state):	☐	☐	☐

3. How important are adaptation capabilities on the following layers?	Un-important	Of little importance	Somewhat important	Important	Very important
Socio-economic	☐	☐	☐	☐	☐
Business processes	☐	☐	☐	☐	☐
Application	☐	☐	☐	☐	☐
Computing infrastructure	☐	☐	☐	☐	☐
Communication infrastructure	☐	☐	☐	☐	☐
Other (please state):	☐	☐	☐	☐	☐

4. How important are adaptive FI applications for the following application domains?	Un-important	Of little importance	Somewhat important	Important	Very important
eHealth	☐	☐	☐	☐	☐
Freight Transport & Logistics	☐	☐	☐	☐	☐
Media	☐	☐	☐	☐	☐
eEnergy	☐	☐	☐	☐	☐
Finance	☐	☐	☐	☐	☐
eTourism	☐	☐	☐	☐	☐
Smart Cities and Utilities	☐	☐	☐	☐	☐
Passenger Mobility	☐	☐	☐	☐	☐
Food and Agriculture	☐	☐	☐	☐	☐
Privacy, Security and Trust	☐	☐	☐	☐	☐
Environmental Observation	☐	☐	☐	☐	☐
Computer and Video Games	☐	☐	☐	☐	☐
eGovernment	☐	☐	☐	☐	☐
Other (please state):	☐	☐	☐	☐	☐

5. Are you from? (multiple selection possible)	6. Comments
Organization: ☐ Academia ☐ Industry (☐ SME / ☐ large enterprise) Activity: ☐ Research ☐ Development ☐ Other	Please use the other side of the questionnaire.

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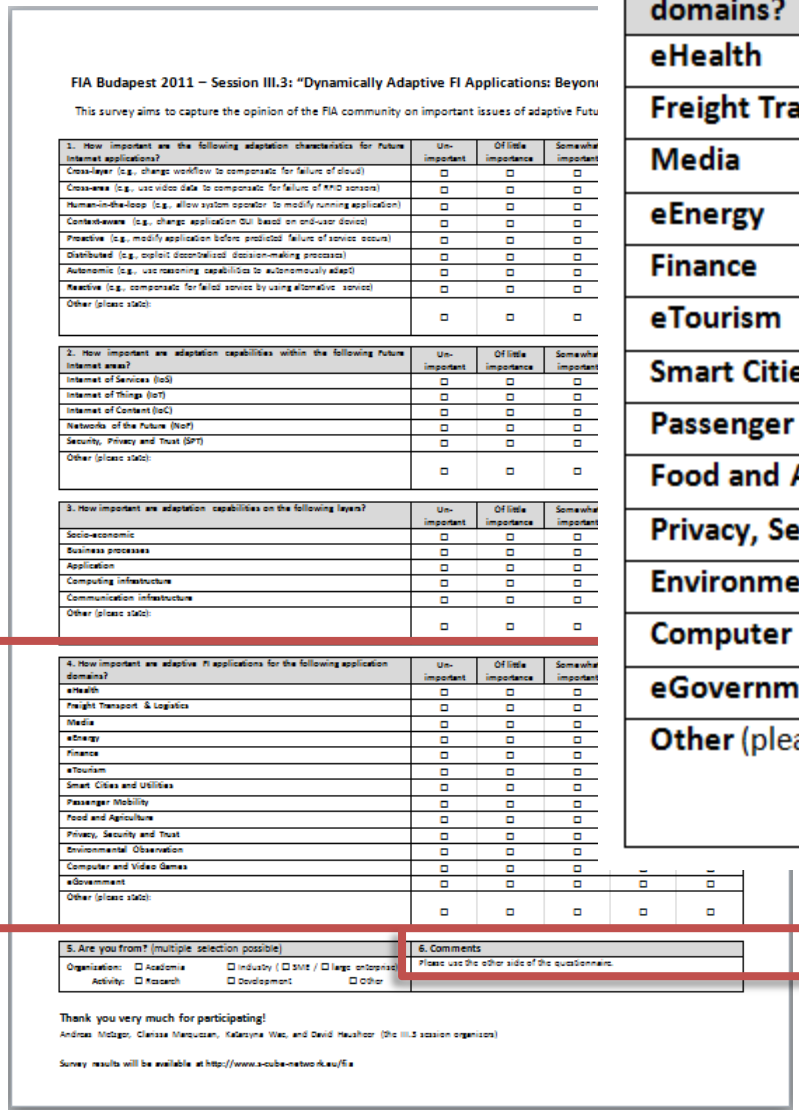
3. How important are adaptation capabilities on the following layers?
Socio-economic
Business processes
Application
Computing infrastructure
Communication infrastructure
Other (please state):

Question 3 (Q3)

Survey Study

- Questionnaire



FIA Budapest 2011 – Session III.3: "Dynamically Adaptive FI Applications: Beyon

This survey aims to capture the opinion of the FIA community on important issues of adaptive Futu

1. How important are the following adaptation characteristics for future Internet applications?	Un-important	Of little importance	Somewhat important
Cross-layer (e.g., change workflow to compensate for failure of cloud)	□	□	□
Cross-area (e.g., use video data to compensate for failure of RFID sensors)	□	□	□
Human-in-the-loop (e.g., allow system operator to modify running application)	□	□	□
Context-aware (e.g., change application GUI based on end-user device)	□	□	□
Proactive (e.g., modify application before predicted failure of service occurs)	□	□	□
Distributed (e.g., exploit decentralized decision-making processes)	□	□	□
Autonomic (e.g., use reasoning capabilities to autonomously adapt)	□	□	□
Reactive (e.g., compensate for failed service by using alternative service)	□	□	□
Other (please state):	□	□	□

2. How important are adaptation capabilities within the following Future Internet areas?	Un-important	Of little importance	Somewhat important
Internet of Services (IoS)	□	□	□
Internet of Things (IoT)	□	□	□
Internet of Content (IoC)	□	□	□
Networks of the Future (NoF)	□	□	□
Security, Privacy and Trust (SPT)	□	□	□
Other (please state):	□	□	□

3. How important are adaptation capabilities on the following layers?	Un-important	Of little importance	Somewhat important
Socio-economic	□	□	□
Business processes	□	□	□
Application	□	□	□
Computing infrastructure	□	□	□
Communication infrastructure	□	□	□
Other (please state):	□	□	□

4. How important are adaptive FI applications for the following application domains?	Un-important	Of little importance	Somewhat important		
eHealth	□	□	□		
Freight Transport & Logistics	□	□	□		
Media	□	□	□		
eEnergy	□	□	□		
Finance	□	□	□		
eTourism	□	□	□		
Smart Cities and Utilities	□	□	□		
Passenger Mobility	□	□	□		
Food and Agriculture	□	□	□		
Privacy, Security and Trust	□	□	□		
Environmental Observation	□	□	□		
Computer and Video Games	□	□	□		
eGovernment	□	□	□	□	□
Other (please state):	□	□	□	□	□

5. Are you from? (multiple selection possible)	6. Comments
Organization: □ Academia □ Industry (□ SME / □ large enterprise) Activity: □ Research □ Development □ Other	Please use the other side of the questionnaire.

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4. How important are adaptive FI applications for the following application domains?	
eHealth	
Freight Transport & Logistics	
Media	
eEnergy	
Finance	
eTourism	
Smart Cities and Utilities	
Passenger Mobility	
Food and Agriculture	
Privacy, Security and Trust	
Environmental Observation	
Computer and Video Games	
eGovernment	
Other (please state):	

Question 4 (Q4)