Interoperability Network - The Internet of Actors

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FORWORD

This document describes our path and the economics of the interdisciplinary Interoperability Network, a so called 'Internet of Actors'. We, the authors, have our background in business mathematics and business informatics. In order to grasp the manifold tasks and to develop the methodical and technological concept of the Interoperability Network, it was important for us to expand our circle of consultants in order to capture and take all requirements and development trends into account. Our closest consultants are therefore recruited from the following areas of expertise:

- Computer Science, Communication Technology, Production Automation
- Knowledge Management, Business Administration with Organizational Science and Business Process Management
- Economics and Socioeconomics

In preparing this document, we have not only felt the language barrier between the classical languages, but above all between the different subject areas. There are numerous cases in which, depending on the discipline, sometimes even within a discipline, the same subject matter has different names. These differences have repeatedly led to long discussions and an intensive search for the "right" word. We hope that we have always found it in this document.

1 Initial Situation

Intra- and inter-company workflows are changing from classic, predefined, inflexible business processes to global, agile value networks. Man, machine and software modules work and communicate integrated and coordinated on application level to achieve their objectives together (interoperability). This requires a new dimension of agility, speed of change, participation and autonomy in business IT.

The so-called platform economy, based on geographical, sector-specific and/or proprietary approaches, leads either to the formation of monopolies (B2C such as Google, Amazon, Facebook) or to a multitude of platforms (B2B). However, all existing B2C platforms show that a platform can only be fully effective if almost all users use the same platform. The B2B platforms enable communication for their respective sub-communities but are not interoperable with each other.

> *This interoperability, which is so necessary, does not exist today [...]. However, there are also market participants who expect benefits from this obstacle: »Those providers whose systems determine the market are generally favoured by this deficit. Here interoperability is an important mechanism for reducing existing economic and technical dependencies, especially for the German, predominantly medium-sized industry«. (1)*

The above quote from Bitkom is not only valid for the German economy but also for the European and even global economy and should be a wake-up call for most corporations. For the business sector this means absolute dependence on the preferred platform provider. (2) In addition to this dependency, a second situation automatically arises that threatens the existence of any enterprise, since a location outside the enterprise is created where all data can be collected and evaluated across all enterprises. The platform providers have sovereignty over everything that happens on these platforms. Since platform customers have no say and no participation, this model is developing more and more into a serious challenge for the digital transformation and Industry 4.0.

Particularly in the business sector, there is often the additional demand and necessity to give more autonomy to the acting employees or divisions of the company to collaborate on the solution of their topics. There is also an increasing need to equip machines/devices with more autonomy in accordance with today's technological possibilities.

We want to ensure and sustain the entrepreneurial diversity and sovereignty of the participants in the digital economy.

The growing social sensitivity towards platforms leads to the conclusion that social development lies in a digital Interoperbility Network and will thus lead to a network economy.

2 Characterization of an Interoperability Network

> *Network commerce has consequences that go far beyond just a business model.*
>
> > *Markets are based on mistrust,*
> > *Networks on trust.*
> > *Markets are based on the pursuit of self-interest,*
> > *Networks on shared interests.*
> > *Markets are arm's-length transactions,*
> > *Networks are intimate relationships.*
> > *Markets are competitive,*
> > *Networks are cooperative. (3)*

The above quote from Jeremy Rifkin shows in an exaggerated way the differences between markets and networks. In the network economy, we are not only talking about a single software application, but an infrastructure for many/all applications.

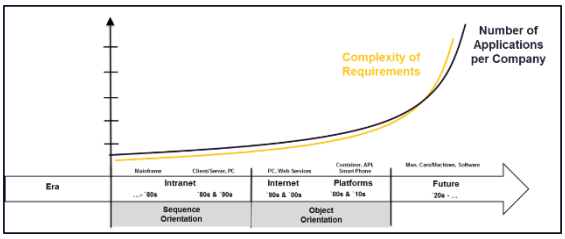

Figure 1 Number of Business Software Applications per Company (Schematic Diagram)

Figure 1 shows how the number of software applications in companies has gradually increased over the past decades, partly because automation has increased. Today, large companies have more than 1000 different software applications in use to support their employees in their work or to manage their workflows. This constant integration task across all systems and releases consumes a large part of the existing IT budget. At the same time, the complexity of the requirements continues to increase exponentially, e.g. due to the IoT, AI and the topics related to Industry 4.0 with their horizontal and vertical integration.

Chapter 2.1 describes the methodological and technical characteristics of an Interoperability Network based on the EU Interoperability Framework (EIF) (4) and Chapter 2.2 explains the organisational characteristics.

2.1 Methodical Technical Characterization of Interoperability

The definition of a network also applies to a (software-based) interoperability network:

> *The term network is generally used to describe structures and systems that consist of a set of elements (nodes) that are linked together via connections. [...] The simple principle of nodes and connections allows a multitude of different architectures. Networks form open structures that are able to expand without boundaries and to integrate new nodes as long as they are able to communicate within the network. (5)*

Both (software) nodes and connections must be defined in the interoperability network.

The EU has generally defined interoperability as follows:

> *Interoperability is the ability of organisations to interact towards mutually beneficial goals, involving the sharing of information and knowledge between these organisations, through the business processes they support, by means of the exchange of data between their ICT systems. (4)*

In addition to the written definition, we also see in Figure 2 the profound meaning of the term interoperability for the digital world. The interdisciplinary stack for interoperability is created.

Figure 2 EIF-Layers (4)

A distinction is made between four layers of interoperability. Although the layers build on each other, the aim is to develop the layers as independently as possible.

- Technical Interoperability

  The layer at which all basic technical agreements are made that enable meeting the requirements of the upper three layers; here the nodes and connections of the interoperability network are defined;

- Semantic Interoperability

  The layer that ensures that the organisational, content, communicative and legal requirements are described in such a way that they can be

implemented with the technology agreed at the layer of Technical Interoperability;

- Organizational Interoperability

  The layer at which all organizational and context-relevant facts are described and specified between the participants resp. those responsible on the basis of the agreed semantics;

- Legal Interoperability

  The layer at which the legal framework is coordinated by the parties involved. For the digital world, the legal framework is also described in semantics. From this follows automatically the requirement on the involved parties to determine these rules so exactly that the guidelines allow a technically distinct processing.

The technical and semantic interoperability layers and their derived scope of services thus represent the software infrastructure for all layers in the EU Framework. This is the prerequisite for global value creation networks.

2.1.1 Technical interoperability with its communication at application level

Internet of Things, Internet of Everything, Industry 4.0, Networked Economy and Digitalization imply the vision of a global communication network on application level (Interoperbility Network). The particular challenge is the inter-company communication, which requires the interoperability of all digital network nodes. Global interoperability can only be achieved through standardization.

Over the past four decades, the telecommunications industry and the IT industry have shown that standardized, global communication networks generate enormous wealth effects. The Internet and the global mobile network are the most prominent examples. Global communication networks fulfill two mutually dependent requirements, they are supported by a largely democratically organized community, and the technologies and architectures used offer members of the community the opportunity to participate.

A sustainable digital, global communication infrastructure on application level (Interoperbility Network), which enables its users to participate, can be identified by the following criteria:

- scientifically proven
- unique, modular, standardized, interoperable,
- democratic, regulated, non-discriminatory
- decentralized, horizontal

Standardization in the field of communication technology has always led to a great leap in the dissemination of technological progress in recent decades. At the same time, standardization has always laid the technical foundation for a new market. Based on a common standard, a wide variety of devices and software solutions are developed that are interchangeable thanks to standardized communication. Standardization prevents the lock-in effect to hard-and software vendors (vendor lock-in) and at the same time guarantees the diversity that is desired and necessary in social policy. Examples are the GSM protocol for mobile communication as well as the TCP/IP protocol for the expansion of the Internet.

Figure 3 shows in exemplary fashion this development since the 1970/80s, when the OSI 7-layer model (6) was developed. Over time, one layer after another was standardized, and thus, on the one hand, the vendor lock-in was pushed back and, on the other hand, the manufacturers of software applications no longer had to develop the communication layers. This was just one reason why less IT and comomnication expertise was required for software application development.

At the same time, however, the scope and complexity of the requirements increased steadily. Another driver for increased complexity will be the IoT with its trillions of software modules just as the ever faster change of business models requires a new dimension of software agility.

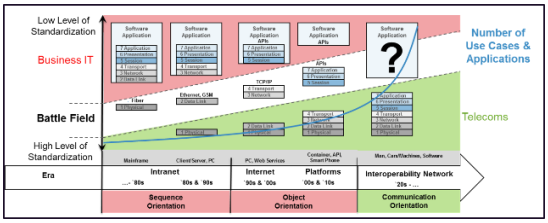

Figure 3 Impact of New Communication Standards on Business IT (Interoperability Network and Communication Orientation)

In order to overcome this increase in complexity and avoid the lock-in effect of the platforms, an Interoperbility Network must be created in which the digital nodes connect via a universal and standardized communication protocol.

In an Interoperbility Network, software applications are created by connecting autonomous software nodes. This means a paradigm shift for the development of software applications. The focus is no longer on object orientation, but on the communication of the digital nodes.

2.1.2 Semantic Interoperability as a Basis for the Simplicity of Software Application Development

The creation of software has developed considerably over the past decades and has become simpler in many ways. (see also Figure 4) In order to program a fixed scope of services, only a fraction of the effort and knowledge required in the 1970s and 1980s is required today. Programming languages have become more powerful, and

object orientation in particular has led to a considerable increase in performance. Today, small and singular tasks can be programmed and solved very quickly.

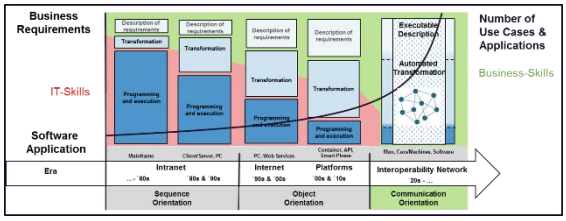

Figure 4 Change in the Allocation of Tasks in the Software Development Process

Figure 4 shows how the software development process has changed over the decades. In order to illustrate the change, especially the manual effort, one can define the following three areas for the division of work in the software development process:

- Description of Requirements

  comprises all work from the analysis of the task to the optimization of the way of working and processing. Various tools are available for this implementation, from pure text systems to complex model languages such as BPMN. The required expertise in this area is characterized by the required business requirements and less by IT knowledge.

- Transformation

  contains the work that is necessary to develop an IT concept from requirements. This also includes tasks such as integration into the existing IT landscape and synchronization of the various IT teams. Working methods such as SCRUM are used in this segment to resolve misunderstandings and translation errors as quickly as possible. In this area, expertise in business, organization and IT, including programming, is required.

- Programming and Execution

  contains the programming in the respective programming language with the corresponding tools and the execution on the target system including all necessary testing and operating conditions.

Due to the increasing complexity of business requirements, the description of requirements segment is increasing in relation to total effort. (see also Figure 4) The same effect can be seen in the segment of transformation, which has expanded considerably over the decades due to more complex tasks, larger project teams, the dissolution of software monoliths into smaller service units and the need for integration into existing IT landscapes. In the segment of pure programming, on the other hand, the relative effort has decreased considerably in recent years, also due to the larger performance volume of programming languages and their tools.

Figure 4 shows that the current software development process will collapse with an exponentially increasing number of software applications unless it is fundamentally simplified and automated. Only then can it meet the user requirements of an Interoperability Network.

The following functionalities are required:

- Definition of (software) nodes and connections to enable the multi-use (also automatic) of each node.
- Autonomy of the software nodes to replace orchestration by choreography (7) and thus achieve agility at node level.
- simple semantics based on nodes and connections to describe business requirements
- immediate executability of semantics (Turing complete)
  - to eliminate the costs of transformation, misunderstandings and translation errors
  - to reduce the knowledge required for programming and execution

Above functionalities ensure that a software application is established in the Interoperbility Network and that the Description of Requirements and the Programming & Execution segments merge into a new segment called Executable Description. The transformation segment is simplified and therefore requires much less effort.

Based on the specifications made in the areas of technical and semantic interoperability, the organisational and legal requirements are identified, defined and implemented.

2.2 Organizational Characterization of Interoperability

The technical and methodological approach of an Interoperbility Network is supplemented by economic and social considerations. Standardization is an important prerequisite for global interoperability.

An Interoperbility Network is like a digital economic space with a single type of product - software.

It needs democratic structures for standardization, participation of users and ongoing technical and economic development. This must be ensured by an ordoliberal framework.

2.2.1 Governance

Governance also plays an essential role in a digital economy and must be future proof. Governance structures of successful digital communities can serve as guidelines, such as those of the IHE community in the healthcare industry. (8)

2.2.2 Guidelines for the governance of an Interoperability Network

- Participaton: Membership should be open to all interested parties. Private sub-communities (e.g. companies, countries, etc.) could adopt their own rules and structures within the framework.
- Transparency: Fundamental information on governance, activities and decisions should be accessible to all users.
- Representation of users: The Governance and all administrative activities are representing the will and the needs of a wide range of users
- Scientific support: Consulting accompaniment and partnership by scientific organizations are of crucial importance to ensure the further development to the benefit of the users.
- Representation of the industry: The commitment of providers in the IT industry (hardware, software, system integration, IT operations) is substantial for the marketability of an Interoperability Network.
- Non-partisanship and balance of interests: No special interest should dominate the decision-making processes.
- Efficient decision-making structures: Decisions should be taken through procedures that ensure that all opinions are taken into account. There should also be a dispute settlement process.
- Consensus: In all decisions, the greatest possible consent by users should be sought.
- Competition: Users of an interoperability network include business organisations that compete directly with each other. The governance of an interoperability network must therefore ensure compliance with the relevant legal requirements, including antitrust law.
- Relevance: The governance of an interoperability network should pay particular attention to the applicability of the technologies and structures developed.
- Effectiveness: Decisions should be designed in such a way that they can be implemented as quickly as possible.
- Interoperability orientation: Sustainable Interoperability should be given the highest priority in the further development of an Interoperability Network.

2.2.3 The Value of an Interoperability Network for the User

The value of any infrastructure increases with the number of users. For an Interoperability Network, mechanisms should be developed to reward early adopters. For example, usage certificates could be issued which, similar to tokens in Blockchains, grow in value with increasing usage.

2.2.4 Digital Management of an Interoperability Network

An Interoperability Network becomes a value creation network through the economic activities that take place on it. This value creation network with its users and rules can be completely digitally modeled. It ensures that all agreements are executed as negotiated between the users. The digitization of the management of an Interoperability Network will affect all areas:

- Project management, controlling and partner and human resources management
- Knowledge management, quality assurance and user training
- Legal management, the accounting of all services and the coordination of users along the governance.

An Interoperability Network can provide a global digital marketplace to enable users to trade software applications and business choreographies. All functions and processes on such a marketplace can be executed digitally. Standardization and interoperability ensure that by design interoperable software applications are provided (technical matching). All users can join the marketplace.

Such a marketplace should essentially meet the following criteria:

- High scalability and reach
- Exclusively quality-assured software applications and business choreographies from certified providers/users
- Individual pricing and remuneration of the providers/users in accordance with agreed compliance
- Closed sub-marketplaces or multihoming for users, user groups or industries

3 Economic Aspects in an Interoparability Network

In a software infrastructure as represented by an Interoperability Network, software shows specific characteristics such as:

- high production costs in relation to lowest marginal costs
- complex protectability
- costly proof of use

The associated difficulties of valuation and remuneration mechanisms deserve special attention.

In order to address the problem of the valuation of software, the valuation for the use of the Interoperability Network could consist of two components, a base component and a market component.

A base component can be automatically calculated using a predefined algorithm and distributed to the users involved in development or operations. Each software application

should have a base component to ensure a fair minimum remuneration of the users.

A market component that can be freely negotiated among all participating users of the Interoperability Network can be added. This process can also be implemented largely digitally.

All rules and processes for valuation should be continuously adapted by the members and committees of the Interoperability Network.

4 Market Potential of an Interoperability Network

An Interoperability Network should provide an attractive, fair and performance-oriented framework for all users.

By establishing global, interoperable B2B value creation networks, the size of the expected economic area can far exceed that of the existing Internet. It can be assumed that an increasing migration of proprietary IT systems and platforms into a global Interoperability Network will take place. This can create a global Network comparable to the Internet or mobile networks.

In the long term, the available global market potential of an Interoperability Network can reach the aggregated global market volume forecasts for the IoT, Industry 4.0 and digitalization in general. The level of welfare gain for the international community can only be imagined and should be many times higher.

A global Interoperability Network offers attractive strategic investments in a sustainable ordoliberal digital space. Users maintain their independence, and investors make targeted long-term commitments.

5 The Internet of Actors as an Interoperability Network

In order to achieve the characteristics of the Interoperability Network, actnconnect has developed a modular software network architecture based on scientific methodologies. The core of this network are the nodes we call Smart Actor (9). We therefore call the Interoperability Network 'Internet of Actors' (IoA).

Software applications on the Internet of Actors consist of any number of independent and interoperable Smart Actors. Software applications are created agilely and dynamically using the ability to connect Smart Actors in a standardized way. This results in cross-company value creation networks. (see also (9))

Besides the governance and the economic view on the Internet of Actors, we will focus in particular on the following for the remainder of this document:

- the technological developments leading to the decentral and interoperable Internet of Actors, and
- the possible framework to ensure fair remuneration for the services provided by each member.

The scientific technological core of the Internet of Actors is described in the white paper "Internet of Actors, a Peer-to-Peer Value Creation Network" (9) by actnconnect.

The Internet of Actors covers the following main topics, which must be further elaborated by the community of the Internet of Actors:

- Governance of the Community
- Smart Actor Economy
- Community Management

5.1 The Software Building Blocks of the Internet of Actors

The Smart Actors (software nodes) are the smallest self-sufficient value creation building blocks of the Internet of Actors. To simplify the requirements gathering these Smart Actors are available in three basic variations: Business Actor, Service Actor and Physical Actor (see also Figure 5).

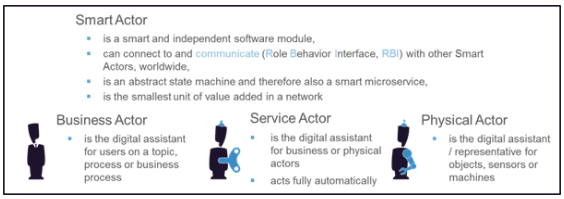

Figure 5 The Smart Actor as the Incremental Software Building Block

The Smart Actors communicate with each other (network connections) utilizing a to be standardized universal protocol which we call Role Behavior Interface (RBI). (9)

The definition of the Smart Actor with its three basic variations and the RBI result in a universal modular software system. From these basic options, an infinite number of individual task-specific Smart Actors can now be modeled. With this software toolkit, all domain-specific functions of the value creation networks can be implemented. The domain-independent Smart Actor Operating System (SmAOS) is added to this toolkit. (see also Figure 6)

This separation of individual functionalities and the operating system for value creation networks in connection with the communication of the Smart Actors ensures that each Smart Actor has its own independent

versioning on application level. This allows to run the release cycles of the SmAOS and the Smart Actors separately.

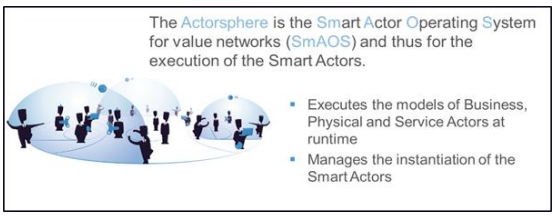

Figure 6 Actorsphere

To ensure the technical interoperability according to chapter 2.1.1 we offer this modular software toolkit. It consists of:

- Smart Actors, and
- the Smart Actor Operating System, as well as contained therein
- the cross-domain Role Behavior Interface (RBI) connecting all building blocks.

5.2 The Requirements Gathering in the Interoperability Network

According to Figure 4, column "Communication", the segment of transformation is minimized despite the increasing complexity of the requirements because, with the help of the modular software design and the semantics of this modular software design, the structure and communication of each software node is unified and standardized. We call this semantics "Internet of Actors Notation" (IoAN). As a result, the IT knowledge required is considerably reduced, because the IoAN is a straightforward semantic for describing business requirements which enables immediate execution in the SmAOS. (Turing complete (9).

Many communicating Smart Actors result in a software application or what we call a business choreography. (see also Figure 7)

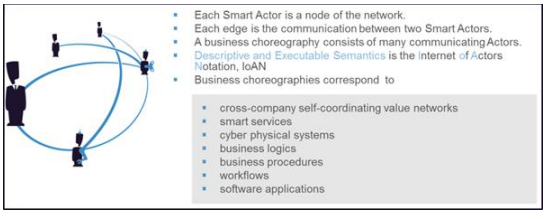

Figure 7 The Business Choreography of Value Networks

A core feature of business choreographies is that all Smart Actors are autonomously acting units. This also implies that each Smart Actor has access to all information about its communication behavior and all required rules.

Autonomous systems such as Smart Actors therefore no longer require an orchestrating body. This characteristic leads to the name Business Choreography. Each Smart Actor can be used in 1 to n business choreographies, and the SmAOS identifies potential communication partners automatically. This will lead to a very high re-usage probability and thus to a high number of uses.

The IoAN's scope of services is synchronized with that of the Smart Actors and SmAOS building block system, so that any complex and interoperable business choreographies can be created as value-added networks.

5.3 Interoperability in the Internet of Actors in all Layers

Summarising the previous chapters, we see that the issue of interoperability, as elaborated by the EU, has not only been met, but in some respects further completed. From the perspective of the Internet of Actors, the definition of interoperability is then as follows:

> *Interoperability means that software building blocks can communicate with each other according to the agreements of the partners and work together towards common goals. This is independent of the producers of software building blocks involved. It includes*
>
> - *communicating peer-to-peer with each other,*
> - *working together as intended, even in complex, global value creation networks and business processes, and*
> - *supporting and enabling collaboration between man, machine and software.*

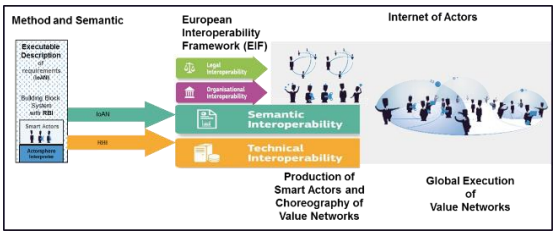

Figure 8 Positioning of the Interoperability Network in the EIF (4)

This results in the following implementation and extension of EIF's interoperability when using the modular software system: (see also Figure 8)

- Technical Interoperability is ensured in the IoA by the modular system with the structure and definition of the Smart Actors, together with the RBI as communication protocol and the SmAOS.
- Semantic Interoperability is ensured by the IoAN semantics with complete synchronicity to the technical structure in combination with immediate executability (Turing complete).

- Organizational Interoperability is achieved when a business choreography is agreed between all participants and used in the IoA.
- Legal Interoperability is achieved when legal requirements are translated into clear rules in a business choreography and these become part of the relevant Smart Actors.

5.4 Tiers of the Internet of Actors

The IoA in its structure and the used methods results in the development of four Tiers for business concepts. (see also Figure 9)

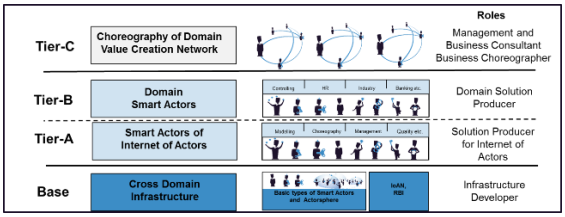

Figure 9 Community Tiers of the IoA

Base
The base is the foundation of the Tiers A to C. This level is a cross domain infrastructure level. Here the central components of the basic types of Smart Actors, RBI, SmAOS and IoAN are developed and made available to all other Tiers as a basis.

Tier-A
At this level you will find all Smart Actors and Business Choreographies that aim to create tools for the Interoperability Network, e.g. for modeling, choreography, management, quality assurance, selection, accounting, etc. The Smart Actors and business choreographies of this Tier are mainly used across domains. However, domain-specific tools can also be created.

Tier-B
At this level, the Smart Actors are developed for each individual domain. A domain can be an industry as well as a defined subject area. However, a Smart Actor created for one domain can also be used in all other domains.

Tier-C
Based on the Tier-B domains, in Tier-C the business choreographies of the respective domain are compiled tested and executed.

For better orientation, we have assigned the roles commonly used today in the process from management consulting to programming to the above Tiers in the IoA. See Figure 9.

5.5 The Community Members of the Internet of Actors and their Tasks

From a business point of view, the first thing we notice in Figure 10 is all Tier-C participants. At this level, domain-specific business knowledge is necessary. This is where the contextual structure of the to be created domain-specific value creation network is designed and defined. The required Smart Actors are selected with a matching process or produced in Tier-B. A lively exchange and communication between the aadjacent levels is indispensable.

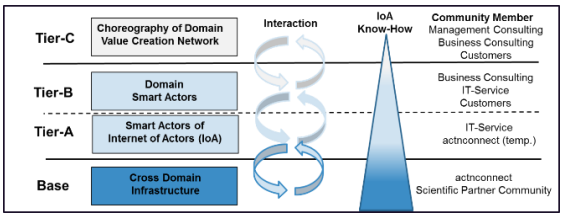

Figure 10 Interaction between Tiers

Tier-B and -C use the Smart Actors and business choreographies of Tier-A as tools for their work. From Base to Tier-C, this distribution of tasks will result in a decreasing need for expertise in the methodologies of the Interoperability Network. However, an in-depth exchange on the business requirements will be necessary to ensure the further development of the Base and the Tier-A.

Each member of the IoA Community can take on any role depending on their competencies. There are the roles of customer/user and, as shown in Figure 10, developer, producer and business choreographer.

6 Conclusion

> *However, a universal plug-and-play in Industry 4.0 is an illusion. There will be no Industry 4.0 standard in the near or distant future to ensure universal interoperability for machines and equipment of all kinds. Even the meanwhile intensified cross-industry standardization efforts cannot and will not achieve this. (1)*

This document shows that the technological development has overtaken the above statement.

The next evolutionary step in the standardization of communication is the interoperability of software applications. With this, the development of a global Interoperability Network can now be initiated.

We believe that for the global community the digital economic space of this Interoperability Network will be the democratic alternative to the platform economy, Open Source or Open API initiatives.

We call such global Interoperability Network the 'Internet of Actors'.

In order to ensure technical and economic sovereignty for the users of the Internet of Actors, a scientific foundation of the used technologies and the rigorous decentralization of all activities are required. This is supported by the inherent interoperability of software applications and the transformation from programming to modelling. The Internet of Actors software architecture ensures maximum automation and scalability. The result is software interoperability by design.

An ordoliberal framework ensures sustainable governance and fair remuneration for the services provided and used by the users of the Internet of Actors.

Communication itself represents a large part of economic activities. With the Internet of Actors, a global trillion USD eco-system is emerging which offers previously impossible efficiency gains for the benefit of common welfare. The avoidance of monopolies and dependencies alone justifies the efforts to build it.

We invite all players in scientific, economic and political life worldwide to play an active role in shaping the Internet of Actors.

7 Acknowledgements and Copyright

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8 List of Figures

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