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Recommendation

ITU-T Y.3140 (03/2023)

SERIES Y: Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities

Future networks

Service brokering network framework for trusted reality

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Recommendation ITU-T Y.3140

Service brokering network framework for trusted reality

Summary

Recommendation ITU-T Y.3140 describes a service brokering network framework for trusted reality featuring application-aware brokering capabilities in terms of context, data and computation. The service brokering network framework for trusted reality aims to deliver a customized immersive application service experience with real-time communication and recognition of knowledge and information in a safe and convenient way for anyone throughout the automated connection of the real and cyber worlds.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.3140	2023-03-13	13	11.1002/1000/15236

Keywords

Edge computing, service brokering, trusted reality.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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1 Scope

The service brokering network framework for trusted reality provides application-aware brokering capabilities in terms of context, data and computation to deliver a customized immersive application service experience. It allows end users to communicate and recognize knowledge and information in a safe and convenient way throughout the automated connection of the real and cyber world.

This draft Recommendation describes the following aspects of the service brokering network framework for trusted reality:

- Background and features;
- Concepts and design considerations;
- Service scenarios;
- Requirements;
- Architecture;
- Procedures;
- Security considerations.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T Y.3130] Recommendation ITU-T Y.3130 (2018), *Requirements of IMT-2020 fixed mobile convergence*.

[ITU-T Y.3131] Recommendation ITU-T Y.3131 (2019), *Functional architecture for supporting fixed mobile convergence in IMT-2020 networks*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 mobility management [b-ITU-T Q.1706]: The set of functions used to provide mobility. These functions include authentication, authorization, location updating, paging, download of user information and more.

3.1.2 network service [b-ETSI GS NFV 003]: Composition of network functions, defined by its functional and behavioural specification.

NOTE – The network service contributes to the behaviour of the higher layer service, which is characterized by at least performance, dependability, and security specifications. The end-to-end network service behaviour is the result of the combination of the individual network function behaviours as well as the behaviours of the network infrastructure composition mechanism.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 service brokering network: The network with application-aware service brokering capabilities in terms of context, data and computation to realize the trusted reality.

3.2.2 trusted reality: A customized immersive application service experience with real-time communication and recognition of knowledge and information in a safe and convenient way for anyone throughout the automated connection of the real and cyber world.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AB Application Broker

AI Artificial Intelligence

D2D Device to Device

EB Edge Broker

EM Edge Manager

IoT Internet of Things

MAR Mobile Augmented Reality

MCC Mobile Cloud Computing

MEC Mobile Edge Computing

PE Physical Entities

QoE Quality of Experience

SBN Service Brokering Networks

SM Service Manager

TR Trusted Reality

URI Uniform Resource Identifier

VE Virtual Entities

5 Conventions

In this Recommendation:

The keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this document is to be claimed.

The keywords "is recommended" indicate a requirement which is recommended but which is not absolutely required. Thus, this requirement need not be present to claim conformance.

6 Overview of service brokering network framework for trusted reality

6.1 Backgrounds and features

The future of mobile service is increasingly gaining traction with wearables as post-smartphones, especially as immersive applications such as mobile augmented reality solutions which are expected to hit the market. Mobile augmented reality (MAR) augments a real-world environment with computer-generated sensory information such as text, sound, and graphics. With advanced MAR

technologies, the information about a person's surrounding physical environment can be brought out of the digital world and overlaid with the person's perceived real world. MAR will be widely adopted in various industries such as tourism, entertainment, advertisement, education, manufacturing and so on.

Mobile edge computing (MEC) is a new networking paradigm in which computing nodes are placed in close proximity to mobile devices for highly responsive cloud services. Leveraging MEC, cloud-based MAR systems can further improve their responsiveness and potentially enable large-scale services. However, it is not trivial to push cloud servers to the edge of the network because edge servers are usually less powerful than cloud servers.

The Internet of things (IoT) is another paradigm that connects a plethora of physical objects to the Internet and enables them to make intelligent decisions. However, the centralization of cloud computing and the growing traffic demands of IoT may result in huge bottlenecks degrading the network performance. Edge computing architectures could potentially overcome the drawbacks of this approach, moving service provisioning closer to the network edge.

But we need a holistic approach to improve the robustness of edge computing architectures for IoT to face the dynamic characteristics of wireless network traffic, which bring intermittent connectivity with objects and consequently degrade data quality. Furthermore, in the process of moving service provisioning toward the edge, mobile devices keep advancing technologically and getting smarter with regard to communication and computing capabilities. However, these capabilities have not been fully explored yet in the IoT context.

Accordingly, the service brokering network (SBN) framework for trusted reality has key technical features that should be considered as follows.

- At the heart of future mobile services is the trust principle where privacy and security for confidential information should be guaranteed thoroughly.
- Next-generation smartphones should be able to respond intuitively, especially from the perspective of viewers. This intuitive feature specializes in services of the post smartphones era from the end user's perspective.
- With the influx of videos, games, and applications day after day, one cannot afford to install and execute those content in a passive manner that was done before for conventional smartphones. A highly efficient way to provide exact service to the end users with limited resources around them is needed.
- Post smartphones should go along with the social trends that feature sharing and openness to allow tailored service offering with disparate types of devices, clients and contexts. Especially preferences of individual customers as well as their environments such as things and devices should be considered.

6.2 Concepts and design considerations

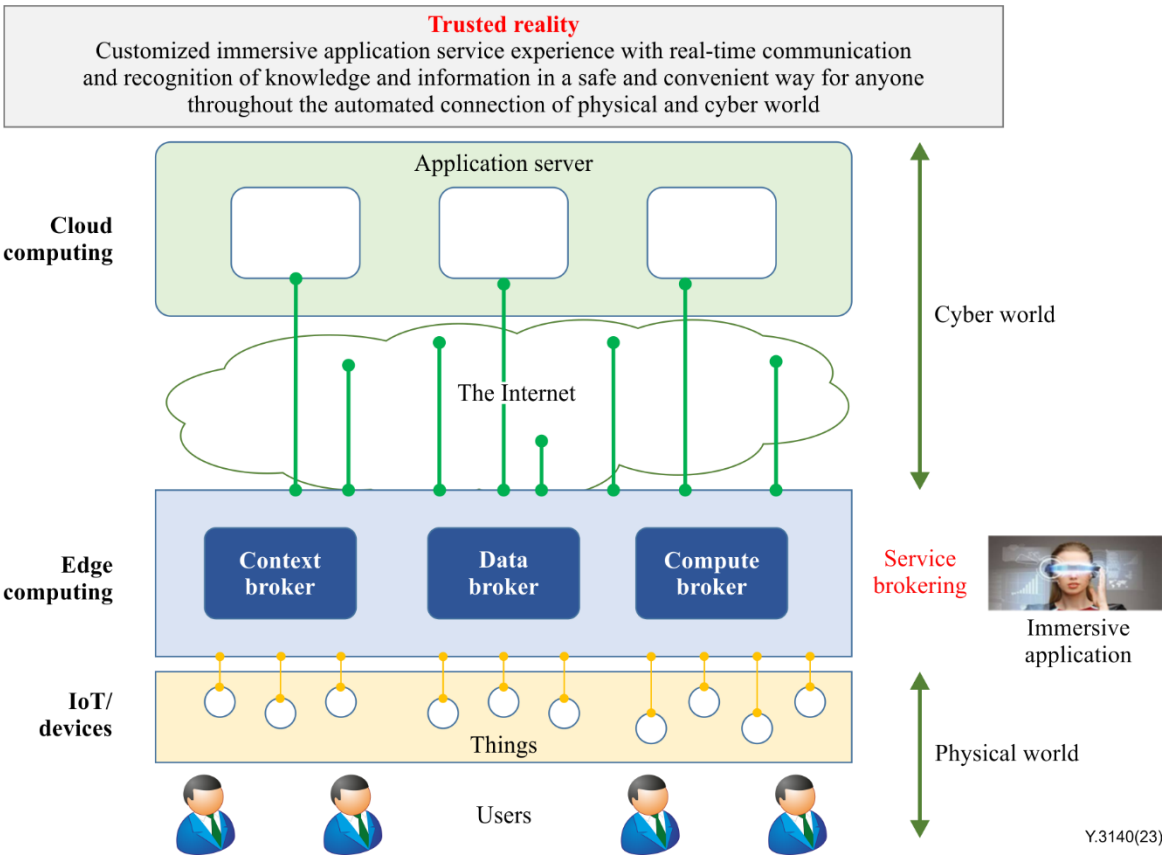

Figure 6-1 – Conceptual diagram of SBN-TR

As introduced, the service brokering network for trusted reality (TR) encompasses IoT and MAR applications in the context of trusted reality as shown in Figure 6-1.

Trusted reality is defined as a customized immersive application service experience with real-time communication and recognition of knowledge and information in a safe and convenient way for anyone throughout the automated connection of the real and cyber world.

Trusted reality is distinguished by its real-time customized immersive experiences offered with automated real-cyber interconnection based on trust features such as safety and convenience compared to augmented reality which is defined as an interactive experience of a real-world environment where the objects that reside in the real world are "augmented" by computer-generated perceptual information, sometimes across multiple sensory modalities.

There are three service brokering functions to realize trusted reality. Firstly, context brokering refers to the provision of customized services according to the situation of three elements: things, devices, and network elements based on their conditions and predefined rules. It is necessary to provide services based on personal tendencies or profiles and to provide application services linking information from IoT devices such as sensor data.

Data brokering provides the necessary services by dynamically linking the actual data such as the video stream that comes from the above three elements to the one that needs them. Data can be compressed and optimized between layers through filters. It is used relatively in applications for processing a large amount of stream information compared to context brokering.

Compute brokering is used for offloading, device to device (D2D) collaboration, and inter-layer collaboration of edges. This can be an intelligent collaboration based on artificial intelligence (AI) or

the collaborative use of the computing power of things or devices and the device power of the network layer.

6.3 Service scenarios

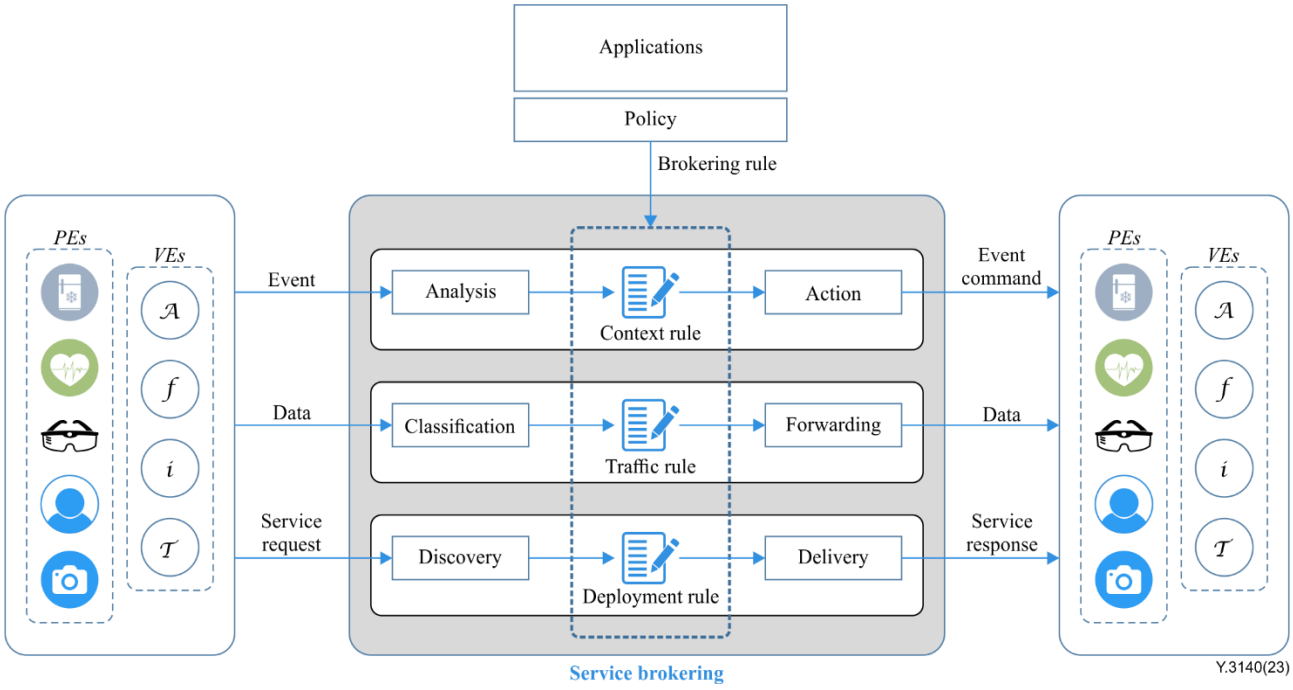

Figure 6-2 – Service scenarios of SBN-TR operations

Figure 6-2 illustrates service brokering services to create new applications by connecting physical and virtual entities.

The service brokering networks – trusted reality (SBN-TR) service brokering supports the interaction in and between physical space and virtual space. The physical space represents a real world consisting of physical entities (PEs) such as sensors and devices while the virtual space in the cyber world has disparate types of virtual entities (VEs) including functions, applications, information, etc.

Context brokering follows the context rules based on the policy of the application service. This means that event information from the physical or virtual entities can be communicated to other entities or controlled by the context rules according to the policy of applications. For example, when event data come from multiple functional sensors, the context broker applies the corresponding rules on the received data and conducts available actions: delivery of sensor data to virtual or physical entities or replying with the corresponding command such as control of the other sensors.

Data brokering follows the traffic rules based on the policies of the application services and serves to receive data traffic from the physical-virtual entities and transfer it to other entities as needed. The representative use case of data brokering service is streaming data interconnection. Video streaming from a camera could be transferred to the designated display or devices or virtual entities such as face recognition or object recognition for AI services. Data brokering service gives another use case that multiple virtual entities could be chained for single streaming data as well.

Compute brokering receives service requests from real-virtual entities, discovers the service, and routes the service request to the destination by the deployment rules based on the policies of the application services. Compute brokering is mostly used for service offloading from the devices to the networks because devices would not be able to desirably perform due to insufficient computing resources available. Another use case of compute brokering is the customized service for users who

are challenged in recognition such as intellectual, visual and hearing. Compute brokering enables providing appropriate services for them followed by the recognition and identification process.

7 Requirements of service brokering network framework for trusted reality

7.1 Orchestration for immersive application

SBN-TR has the following requirements to provide the user with the microservice-based cognitive functions required for the immersive application services in an optimal location close to the user based on policy. The scope of orchestration in this context covers the discovery, deployment and execution of functions to deliver immersive services to the users.

- SBN-TR is required to support the deployment and execution of the required application services based on the user's location and the response time of the application service.
- SBN-TR is required to provide the necessary application service functions to augment the cognition required by the user based on the user's profile.
- SBN-TR is required to support the deployment and execution of the required application services based on intuitive information, such as the viewpoint of the end users on wearables.
- SBN-TR is recommended to deliver application services both in a proactive manner according to predefined service specifications and in a reactive manner provided on-the-fly, depending on the event.

7.2 Resource optimization for access and edge network

For the optimization of application services over access and edge networks, SBN-TR has the following requirements to deploy and execute micro-services, considering the available resources of access and edge networks.

- SBN-TR is required to support monitoring the quality of the deployed and running applications and the health of the infrastructure resources.
- SBN-TR is required to support service rearrangement and reconfiguration based on the monitoring information.
- SBN-TR is required to support the distribution of the microservices, the unit functions that make up the application, across access, edges, cores, and clouds, considering the computing load distribution of the user equipment.
- SBN-TR is required to support network load balancing by utilizing the network status of user devices, access, and edges to provide the desired quality of service.

7.3 Access-edge based real-cyber interworking

For real-cyber interworking application services, SBN-TR has the following requirements to collect information to control and interconnect physical and virtual objects based on the viewpoint of users.

- SBN-TR is required to support the identification of nearby physical objects based on visual images through user devices.
- SBN-TR is required to support the collection of information on the identified physical objects including properties and control interfaces.
- SBN-TR is required to support discovering a correlation between identified physical objects and other objects.
- SBN-TR is required to support establishing a data network between objects involved in the application based on context rules.
- SBN-TR is required to support establishing a control network between objects involved in the application based on context rules.

8 Functional architecture of service brokering network framework for trusted reality

This clause identifies functional architecture for service brokering network framework for trusted reality. SBN-TR is located between the real world and the cyber world and plays a role of connecting and interworking them through context-based relaying of various data and events as illustrated in Figure 8-1.

The framework architecture of SBN-TR could be described in terms of layers, planes, and constituent functional blocks. There are two hierarchical layers and two independent planes with four functional blocks which extended across both layers and planes.

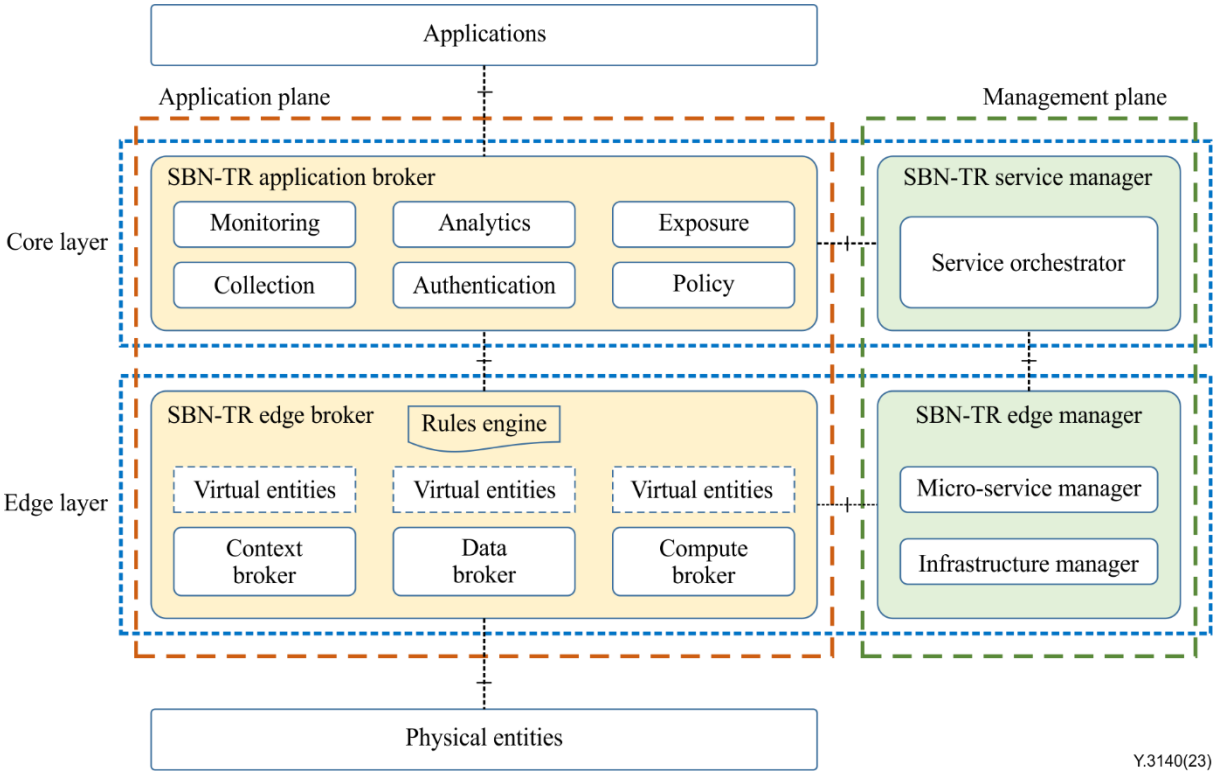

Figure 8-1 – Functional architecture of SBN-TR

8.1 Layers

SBN-TR edge layer consists of a distributed edge node as a point of presence of network service which can take advantage of proximity to provide service at the location close to the user. SBN-TR edge layer can be configured hierarchically, and each layer is optimized for virtualization-based microservices under the consideration of the characteristics of the service.

The SBN-TR core layer oversees the distributed SBN-TR edge nodes to provide network service across the edge network. It also has a role of integration and management of the network service from a point of global view by gathering data from each node involved in network service instances. Integrated data for network service includes operational and management data while network service is up and running for end users.

8.2 Planes

Management plane is to facilitate optimal networking and workload orchestration for underlying SBN-TR infrastructure and covers ranging from provider's network management to virtual resource management to lifecycle management of each network service instance. By the request of the application, the management plane sets up the network service instance across the SBN-TR edge nodes and performs orchestration and management of the created network service instances by the administrative policy.

The application plane is to facilitate secure and manageable interoperability between the application-level interfaces and value-add SBN-TR applications. It works more on the application endpoint. Events that occur while the application service is running are collected at the edge layer and gathered at the core layer to determine the next operation or command to the internal or external entities by the application policy.

8.3 Functional blocks

SBN-TR service manager (SM) functional block, residing at the core layer and belonging to the management plane, is a virtual service management functional block that models virtual services and manages the lifecycle using real-time resource and policy information. Technically it has a feature set of closed-loop virtual service modelling, microservice-based viewpoint networking, cyber-physical system management, and virtual service mobility management technologies.

SBN-TR edge manager (EM) functional block in the edge layer as a component of the management plane is an infrastructure management functional block that creates a virtual network between various virtual objects based on glasses, point of view objects, and augmentation function virtualization, and manages the virtual infrastructure resources. It has technical requirements of dynamic infrastructure virtualization based on viewpoint networking, real-time monitoring over virtual entities and tenant management of the virtual group.

SBN-TR application broker (AB) functional block working at the core layer as a component of the application plane has a role of an application level operational management, policy-based application enablement, and real-time control over application service. It has a set of functions including user profile management, authentication and service profile management, and active policy enforcement based on data gathering from the edge layer.

SBN-TR edge broker (EB) functional block is for physical and virtual entities created correspondingly and manages the transfer and exchange of information according to the type of service to be provided in the edge layer on the application plane. Its main role is brokering between entities involved in the specific network service instance by tracking the context of entities from incoming events defined previously in clause 8.2.

8.4 Reference points

Reference points are a way to identify peer-to-peer relationships between functional blocks. Descriptions of the interfaces provide a deeper understanding of how capabilities provided by a producer functional block are exposed to other consumer functional blocks [b-ETSI GS NFV 006].

There are six reference points in the architecture of the service brokering network framework for trusted reality as listed in the following:

8.4.1 AB-EB reference point

The reference point is used for message exchanges between the application broker and the edge broker to support the following interfaces.

– Interfaces for service authentication for the users to access the SBN-TR edge node.

– Interfaces for service discovery to support the delivery of the required services by the users.

– Interfaces for service policy and rule query for the edge node to provide designated service operations.

– Interfaces for information delivery to send the event and data to the edge node where the identification and detection process is running.

8.4.2 SM-EM reference point

The reference point is used for message exchanges between the service manager and the edge manager to support the following interfaces.

– Interfaces for resource management of the edge nodes distributed in the network.
– Interfaces for VE placement management on the edge nodes.
– Interfaces for VE lifecycle management on the edge nodes.
– Interfaces for the link and network management of the network service composed of multiple VEs.

8.4.3 EB-PE reference point

The reference point is used for information exchanges between the edge broker and the physical entities to support the following interfaces.

– Interfaces for data from PEs to EB.
– Interfaces for command from EB to PEs.

Data from PEs refers to the data generated from the PEs including sensor data, streaming data, or control data such as an HTTP request.

8.4.4 AB-SM reference point

The reference point is used for message exchanges between the application broker and the service manager to support the following interfaces.

– Interfaces for application-level service deployment.
– Interfaces for application policy and rollout options.
– Interfaces for service monitoring information such as fault, alarm and status.

8.4.5 EB-EM reference point

The reference point is used for message exchanges between the edge broker and the edge manager to support the following interfaces.

– Interfaces for VE and the broker instantiation.
– Interfaces for VE and the broker instance management including query, update, scaling and termination.
– Interfaces for VE, broker configuration and event notification.

8.4.6 App-AB reference point

The reference point is used for information exchanges between the application and the application broker to support the following interfaces.

– Interfaces for application deployment request and response.
– Interfaces for application policy and brokering rule enforcement.
– Interfaces for application configuration and event notification.

9 Procedures for service brokering network framework for trusted reality

This clause describes representative high-level procedures for the service brokering network framework for trusted reality to clarify how the function blocks work with each other through the defined interfaces in the architecture.

9.1 Procedures for location-based service placement

According to the requirements of service brokering networks – trusted reality (SBN-TR), it is required to support the deployment and execution of the application services based on the user's location considering the response time of the application service. To place the service near the user optimally, SBN-SM should collect and record the information of every edge node in advance. Authentication and authorization processes during the login procedure enable the service to be placed near the

location of the users. The following figure describes the procedure for location-based SBN-TR services placement.

1) SBN-SM requests information about the edge node information to SBN-EM. The edge node information should include location-related information to deploy the VEs.

2) SBN-SM saves the edge node information received.

3) The user logs in to start the service. The user authentication information such as password, biometric, or computer recognition information is delivered to the SBN-AB.

4) SBN-AB performs user authentication with the login information received.

5) After successful user authentication, SBN-AB sends a service provisioning request to the SBN-SM with information on services that are supposed to provide for the corresponding user.

6) SBN-SM queries the service repository about service information which includes service metadata, service deployment options and specification.

7) SBN-SM prepares to start the service instance using the acquired service-related information such as VEs and the virtual link information.

8) SBN-SM determines the edge nodes and the SBN-EM based on the location information and sends a service instantiation message to the SBN-EM.

9) SBN-EM applies VE and virtual links to the virtual infrastructure of the corresponding edge nodes.

10) SBN-EM replies to the result of the service instantiation request with the details of the service instance.

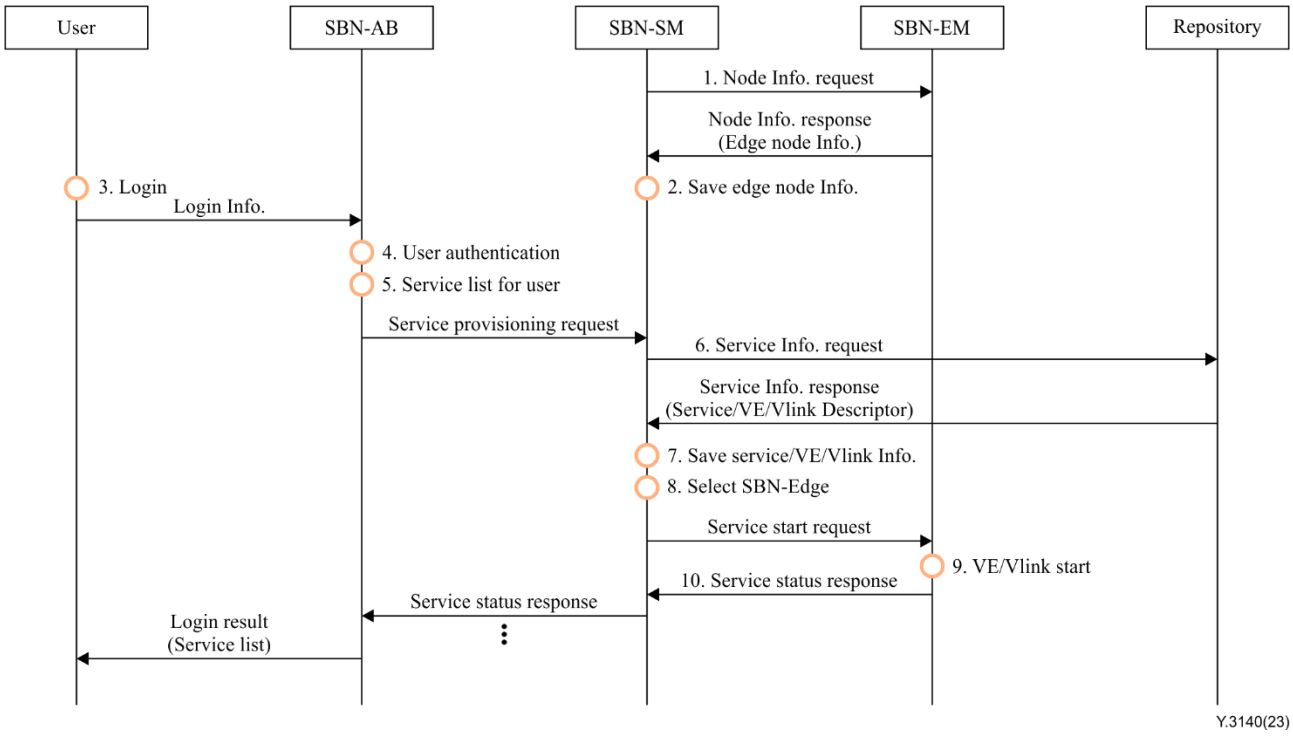

Figure 9-1 – Procedures for location-based service

9.2 Procedures for event-based context brokering service

Event-based context brokering service premises to gather reachable context data from the registered objects and identify defined events to apply actions by context rules. The following figure describes the overall context brokering services in the SBN-TR framework.

1) Define events and context brokering rules in SBN-AB.

2) SBN-AB sends events and context brokering rules to SBN-EB #1 where events and rules over occurred events are applied.

3) SBN-EB #1 monitors data from the physical and virtual objects (Object #1) to check whether the received data value falls within the range defined by the events.

4) Brokering rule is applied to perform the subsequent action defined according to the event identified.

5) In the case of local brokering, SBN-EB #1 takes actions defined in the rule such as the delivery of the event data to other objects (Object #2) or control the objects in the local domain.

6) If the detected event has global significance, the event is delivered to SBN-AB for interaction with other SBN-EB #1.

7) Transfer the event to another SBN-EB #2 to take actions defined in the rule such as the delivery of the event data to other objects or control the objects.

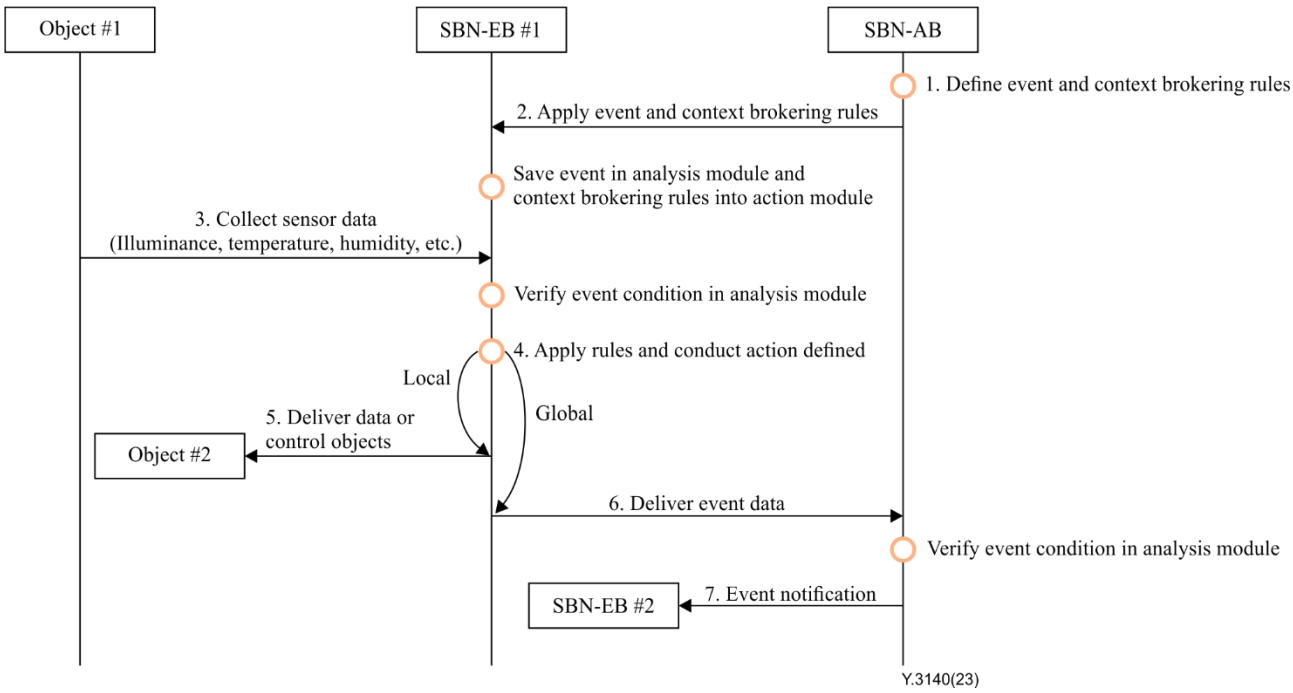

Figure 9-2 – Procedures for event-based dynamic context brokering service

9.3 Procedures for traffic data brokering service

Traffic brokering service determines the traffic directions and conducts traffic steering between physical and virtual objects. One of the representative traffic brokering services is a service chaining service that traverses the traffic by a defined service forwarding graph. The following figure shows the service chaining procedure for a data brokering service in the SBN-TR.

1) Applications request SBN-AB to register service chaining services by connecting VEs.

2) SBN-AB sends service provisioning request to SBN-SM with information on services as described in procedure 9.1.

3) During the deployment of the service, SBN-EM makes a virtual link based on the defined service chain.

4) After the deployment of service in virtual space, SBN-AB creates a forwarding graph for the service chain.

5) SBN-AB sends the forwarding information to SBN-EB.

6) SBN-EB receives forwarding information from SBN-AB and creates connections between physical links and virtual links.

7) When service requests from the object (user) is sent, SBN-EB is the first component that receives a service request.

8) SBN-EB delivers request from the physical link to the mapped virtual link based on the data brokering rule (i.e., forwarding graph).

9) Connect service and response.

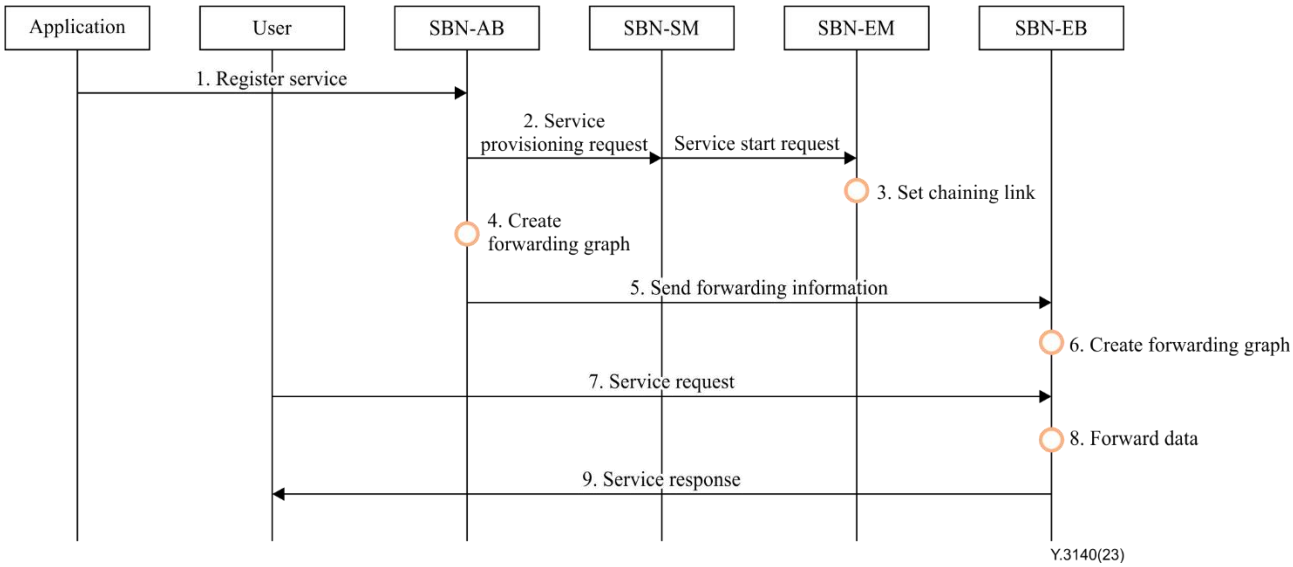

Figure 9-3 – Procedures for traffic data brokering service

9.4 Procedures for compute brokering service

With the increasing number of intelligent applications (e.g., augmented reality and face recognition) that require much more computational power, there is a shift to perform computation offloading to the cloud, known as mobile cloud computing (MCC). Unfortunately, the cloud is usually far away from end devices, leading to a high latency as well as a bad quality of experience (QoE) for latency-sensitive applications. In the procedure, SBN-TR framework extends the cloud to the edge of the network for computation offloading towards edge computing.

The user or physical object does not have application server information available for the desired service. SBN-EB knows the all service list from the SBN-AB and supports the information of the best application server when the client starts service. The following figure describes the procedures.

1) SBN-AB manages the service deployment.

2) SBN-AB sends all the services information to SBN-EB. The service information includes metadata for the service.

3) The user (physical object) requests services with a service ID and service description.

4) SBN-EB performs a service discovery process to find an application (VE) of optimal service.

5) SBN-EB replies with connection information for the service. Uniform resource identifier (URI) or IP and port could be examples of the connection information.

6) User or physical object requests service based on connection information.

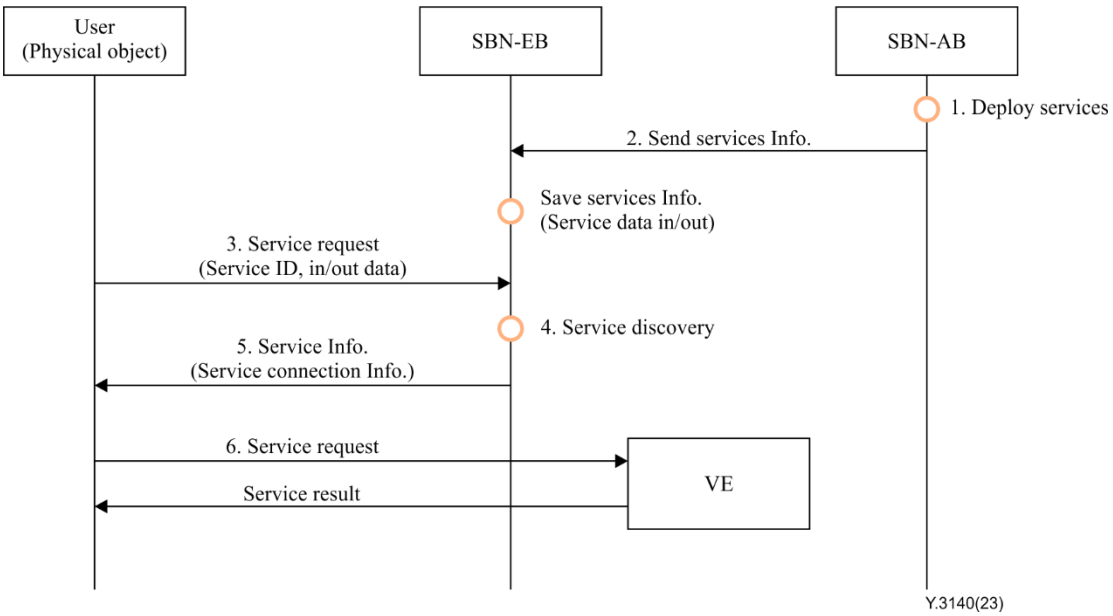

Figure 9-4 – Procedures for computation brokering service

10 Security considerations

The service brokering network framework for trusted reality is required to take into account the issues of security and privacy. The architecture and each component of the SBN-TR framework should be aligned with the requirements specified in [ITU-T Y.3130] and [ITU-T Y.3131] to protect information and avoid unauthorized access to it.

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