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Telecommunications and information exchange between systems — Future network protocols and mechanisms —

Part 2:
Proxy model-based quality of service

Télécommunications et échange d'informations entre systèmes — Futurs protocoles et mécanismes de réseau —

Partie 2: Qualité de service basée sur un modèle de proxy

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Phone: +41 22 749 01 11
Email: copyright@iso.org
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Foreword

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Introduction

This document and ISO/IEC 21558-2 both pertain to the Future Network (FN), which is a broad concept and has a wide application. The FNProxy technology introduced by ISO/IEC 21558-2 enables the future network quality of service (FNQoS), which makes the FNQoS appear to be a mutual relationship between intelligent FNProxies (i.e. harmonization between machines), not like the micro effect of traditional QoS which depends on parameters.

The fact that FNProxy can promote the evolution of QoS to harmonize the process of networking. It provides new forms of networking besides new concepts of QoS. This can lead to the emergence of new industry trends in the field of systems interconnection technology.

This document specifies three engines (perception, negotiation and execution) to support the effective work of FNProxy. This document also describes protocol mechanisms for synchronous interaction between two FNProxies and among multiple FNProxies. Also, conditions and requirements for service transitions between/among FNProxies are described. Annex A gives the quantitative calculation method (harmonization between FNProxies) of interaction QoS effect, which can be used as a starting point reference for developers to improve the calculation method.

Duo to the intelligence of FNProxy, synchronous interactions of Bidirectional Service (Bi-S) between FNProxies have more extensive effects. Bi-S is necessary: a fundamental methodology, tool, and idea to analyse and develop FNQoS systems.

This document explains in detail the protocol mechanisms of FNProxy interactions from two perspectives: 1) the basic FNQoS system (BFS) 2) synthetic FNQoS system (SFS).

This document stipulates that protocol mechanisms can be used for all networks for transmission purposes, and also for generalized networks, such as the implementation of semantic network protocol mechanisms. The development of various network technologies based on Artificial Intelligence Enabled Networking (AIEN) is recommended.

This document stipulates that the purpose of interactions between FNProxies can be either transmission interactions or content interactions.

The protocol mechanism specified in this document is applicable to ISO/IEC TR 29181-8 and ISO/IEC 21558-2.

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Telecommunications and information exchange between systems — Future network protocols and mechanisms —

Part 2: Proxy model-based quality of service

1 Scope

The concept of this document considers the FNQoS related to the FNProxy based in ISO/IEC TR 29181-8.

The protocol mechanism given in this document supports both the interaction between two FNProxies of a basic FNQoS system (BFS) and the interaction among multiple FNProxies in a synthetic FNQoS system (SFS).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 21558-2, *Telecommunications and information exchange between systems — Future Network — Architecture — Part 2: Proxy Model based Quality of Service*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in ISO/IEC 21558-2 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 Terms and definitions

3.1.1
service transition
FNProxy transfers the requirements that it cannot serve to the corresponding FNProxy

Note 1 to entry: FNProxy service transition must be based on the FNProxy's own strategy and real-time information.

Note 2 to entry: That the direction of service transition can also be determined by the information of Bi-Ss (FNProxy link pairs) stored in the *FNProxy Interaction Bridge (FIB)* (3.1.2) of the FNQoS system. By default, the transition direction is based on the information stored in FIB.

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3.1.2
FNProxy Interaction Bridge
FIB
linking path of two FNProxies in SFS

Note 1 to entry: It includes logical paths to realize the interactive exchange of information between any two FNProxies in a synthetic FNQoS system (SFS) consisting of bidirectional service (Bi-S) pairs by cascading.

3.1.3
FNProxy Link Mode
FLM
FNProxy linking template

Note 1 to entry: It is used to normalizing the design, evaluation and calculation of binding, identification, registration, management, bidirectional service (Bi-S) and negotiation for different styles of FNProxy link in a synthetic FNQoS system (SFS).

Note 2 to entry: Several FLMs are listed in Annex D. When FLM is used by the designer, it means that the transition direction of the FNProxy is not random but known in advance. The negotiation strategy (NS) of the FNProxy will set the requirement type percepting function of the perception engine of FNProxy to sleep.

3.1.4
FNProxy Protocol Data Unit
FPDU
data unit needed by the interaction between two FNProxies in an FNQoS system

3.1.5
BFS Protocol
BFSP
set of FPDU fields, semantic changes and timing needed by all procedures supported by the two FNProxies of BFS

3.1.6
SFS Protocol
SFSP
set of FPDU fields, semantic changes and time sequence of all procedures among all FNProxies in a SFS

3.1.7
FNProxy Strategy
FNPS
predetermined response of FNProxy

Note 1 to entry: It is for some important states or comprehensive effects of an FNQoS system based on the environment of FNQoS system, the characteristics and capability of the FNProxy, the target of the FNProxy owner and the real-time running status of the FNProxy.

Note 2 to entry: The FNProxy Strategy (response measures, scheme) and its solutions (sub schemes) are stored in the FNProxy Strategy Base (FSB).

3.1.8
procedure
interaction sequence between FNProxies to complete the special tasks in the FNQoS system

Note 1 to entry: The comprehensive effect of FNQoS system consists of several procedures dynamically. It is generally expressed in the form of a sequence diagram.

3.2 Abbreviated terms

AI	Artificial Intelligence
AIEN	Artificial Intelligence Enabled Networking

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ALF	Access Layer FNProxy
BFS	Basic FNQoS System
BFSP	BFS Protocol
Bi-S	Bidirectional Service
BS	Base Station
ES	Execution Strategy
FIB	FNProxy Interaction Bridge
FN	Future Network
FPDU	FNProxy Protocol Data Unit
FSB	FNProxy Strategy Base
OSI	Open System Interconnection
PDU	Protocol Data Unit
QoS	Quality of Service
SDO	Standard Development Organization
SFS	Synthetic FNQoS System
SFS	SFS Protocol
UML	Unified Modeling Language

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4 Protocol mechanisms in BFS

4.1 Description of BFS

In engineering implementation, UML should be used to express a specific FNQoS system, so as to improve the system's ability to adapt to FN. Attention should be paid to specific QoS requirement in FN environment, and FNProxies should be extracted for dynamic interactivity.

Various FNProxies interactions based on the Bi-S mentioned in ISO/IEC 21558-2 are distributed in an FNQoS system. When these dynamic service FNProxies constitute an FNQoS system, they can be divided into BFS and SFS.

BFS is the smallest FNQoS system. There are only two FNProxies in BFS. Two FNProxies can interact to form Bi-S. Its characteristics are: no matter whether there is Bi-S or not, when the two FNProxies interact with each other, the FNProxies do not need to report the impact of FNProxies to the FNQoS system, nor do they need to register or manage other operations.

The result of the interaction between two FNProxies is FHR. FHR is based on the technical characteristics of Bi-S. See ISO/IEC 21558-2 for technical characteristics of Bi-S. See Annex A for the quantitative method of FHR.

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4.2 General interactive nature for FHR

4.2.1 FNProxy pairing situations

This subclause describes the fundamental mechanism of FNProxy interactions for generating FHR based on Bi-S.

The interaction between each pair of FNProxies in the FNQoS system can contribute to the comprehensive effect of FNQoS system. See Annex A for details. The contribution made by each pair of FNProxy interaction to the comprehensive effect of FNQoS system depends on whether each pair of FNProxies has both requirements and a service.

Figure 1 shows FNProxy A and FNProxy B in the FNQoS system. Both FNProxies can receive the information from the other FNProxy, but their requirements cannot be matched by other appropriate services, the two FNProxies not form a Bi-S. Either way, both FNProxies record and save each other's management information.

The solid line indicates that FNProxy A sends a message to FNProxy B, and the dotted line indicates that FNProxy B cannot feed back to FNProxy A according to its own situation. Figure 1 is the two quasi interactive FNProxies without Bi-S.

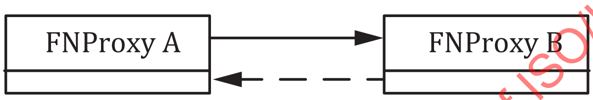

Figure 1 — Two quasi interactive FNProxies without Bi-S

Figure 2 shows the successful pairing of FNProxy A and FNProxy B under the condition of Bi-S effect.

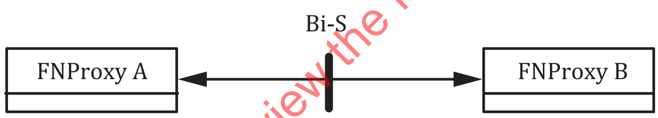

Figure 2 — Interaction FNProxy pairing success in FNQoS system

4.2.2 Active and passive functions of FNProxy

4.2.2.1 Active functions

When an FNProxy in an FNQoS system perceives the environment requirements and knows that it does not have the capabilities to complete the requirements, it will forward the situation to other qualified FNProxies according to its own strategy. The FNProxy's initiative is key. In this way it mimics the natural abilities of humans (i.e. belief, desire and intention).

Other FNProxies receive the information and responded to this FNProxy according to its strategy.

4.2.2.2 Passive functions

In the interface of any FNProxy, the capability and method for other FNProxies to query this FNProxy should be exposed. It is called the INQUIRY method.

4.2.3 Interaction model of BFS with engines

According to ISO/IEC 21558-2, there are three engines (perception, negotiation and execution) in any FNProxy. If an AI algorithm is involved in the three-engine runtime, it can invoke the function of the intelligence resource domain in ISO/IEC 21558-2 and usage strategy. Designers of FNQoS system are not required to study complex AI algorithms when dealing with various FNQoS scenarios.

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The application of AI algorithms should be perception first, then negotiation, and finally execution. The three engines, which work in the following order, are the default configuration of the FNProxy: the perception engine, the negotiation engine, and the execution engine. The process that three engines execute in a sequence is called “the service cycle of FNProxy”.

Figure 3 shows a simplified FNProxy interaction model of BFS (two FNProxies are fnp1 and fnp2). Each FNProxy contains the three engines to work together. Since there are only two FNProxies, the designer will not consider the strategy of handling the transition, i.e. step c in the Figure 3 is represented by a dotted line. When this figure is used to analyse SFS, i.e. when the number of interactive FNProxies is more than or equal to three, FNProxies also transit services according to their execution strategy (ES).

There is also the strategy for FNProxy to generate a requirement. As shown in Figure 3, R1(ES1, E1), R2(ES2, E2): the current execution value E1, E2 of FNProxy A1, FNProxy A2 is respectively converted into the requirement value R1, R2 under execution strategy ES1, ES2.

I1 and I2 show the interference received by FNProxy A1 and A2 respectively.

C1 and C2 show the capability to represent A1 and A2 respectively.

RP1 represents the real-time preference perceived by FNProxy A1.

PS1 and PS2 represent the perception strategies of FNProxy 1 and FNProxy 2 respectively.

The three small black dots marked in FNProxy A2 in Figure 3 are called perception strategy (PS1), negotiation strategy (NS1) and execution strategy (ES1). The strategy point indicates where the strategy is placed by the developer. The interaction framework model of BFS in the Figure 3 can be adapted to complex application scenarios.

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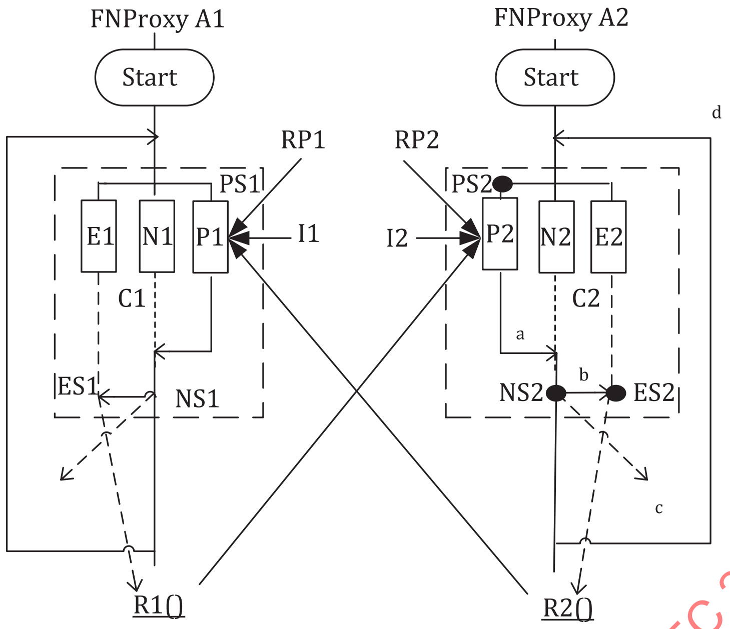

Key

P Perceiving Engine
N Negotiating Engine
E Execution Engine
R Requirement of FNProxy
C Capability of FNProxy
I Interference received
RP Real-time preference perceived
PS Perceiving strategy
NS Negotiating strategy
ES Execution strategy
[a] Judging whether FNProxy capability can meet the perceived requirements.
[b] If the requirements can be met, it will be excuted.
[c] If the requirements cannot be met, transit to another FNProxy based on negotiation strategy NS2.
[d] After this requirement processing, continue to process the next requirements.

Figure 3 — Interaction model of BFS with three engine characteristics

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4.2.4 FPDU definition of BFS

On the basis of traditional PDU, FPDU adds intelligent processing. The FNProxy senses the context change of FPDU in real time, and the FNQoS system can change the networking strategy in real time. Both the traditional communication network and AIEN are formed based on the interaction and cooperation of FNProxies.

The service of one FNProxy processing the other in a pair of interactive FNProxies is not exactly the same as the working service of OSI PDU processing between the lower layer and the upper. Many fields of FPDU are obtained by this FNProxy, instead of being transferred from traditional inter-layer processing. For example, target FNProxy number, this FNProxy requirements and FPDU style can be obtained from the negotiation strategy, execution strategy, and domain name of this FNProxy. If the requirements of this FNProxy cannot be perceived, there will be no FNProxy serving for this FNProxy.

Two FNProxies use BFS Protocol (BFSP) to interact.

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Although there are various forms of FNs involved, FPDU (FNProxy Protocol Data Unit) can be composed of the following basic fields, which can meet the needs of interaction between two FNProxies. The designer of FNQoS application system can inherit and expand these basic fields according to the actual situation. The basic fields of FPDU are: this (Source) FNProxy number, the target FNProxy number, type of FPDU, requirements of this FNProxy and capability of this FNProxy, as shown below. It is abbreviated as: FPDU {Sn, GN, FS, Cap, Req}. The designer of FNQoS application system can inherit and expand these basic fields according to the actual situation.

FPDU

{

SourceNumber; /SN

GoalNumber; /GN

FPDUStyle; /FS

Capability; /Cap

Requirement; /Req

};

The semantics of the fields in FPDU are as follows:

Semantics of FPDU

{

SourceNumber: Source Number

/The value of this FNProxy's number

GoalNumber :Goal Number

/ In FNQoS systems with more than or equal to three FNProxes, the goal number (GN) FNProxy of is generally consistent with the link order of FLM. This is because the link order in FLM is fixed in advance. FLM records the corresponding GN that can be transferred when the FNProxy in the FNQoS system fails to sign a contract.

/ However, GN can also change in real time due to the following factors: the corresponding procedure, the context content, the algorithm of the special FNQoS system and the corresponding operators used.

FPDUStyle:FPDU Style

/When FPDUStyles are 0, 1, 2, 3 and 4, it means that FPDUStyles are more suitable for management, operation, intelligence resource, user and communication domains.

Capability:The FNProxy is given the maximum service capacity

/When the FNProxy provides services for multiple FNProxes, the percentage of the capability allocated to each requirement FNProxy can be obtained according to the needs of the corresponding application scenarios.

Requirement:Current Requirement of this FNProxy

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/It refers to the requirements put forward by the FNProxy to other FN-Proxy according to the contract value and the FNProxy's own strategy before the FNProxy executes the new contract.

/ The type and size of the requirements proposed by the FNProxy vary according to the execution value and execution strategy of the FNProxy.

};

The subfield and semantics of requirement field are as follows:

Requirement

{

Type/ Semantics is the type of requirement

/ Generally, the requirement type is not directly related to the FNProxy characteristics. The requirement type of the FNProxy depends on the effort of the owner of the FNProxy and the strategy for it.

Value / Semantics is the value of requirement

/Value can be expressed either abstractly or concretely. When the requirement is abstract, the abstract expression can give the engineering meaning result of specific technology according to the scene.

};

The subfield and semantics of capability field are as follows:

Capability

{

Type / Semantics is the type of capability

/Generally, the type of capability is directly related to the FNProxy's characteristics, so that it can show the service capability of the FNProxy's own characteristics.

Value/ Semantics is the value of capability

/Value can be expressed either abstractly or concretely. When the requirement is abstract, the abstract expression can give the engineering meaning result of specific technology according to the scene.

};

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4.2.5 Strategy processing scheme in FNProxy

The FNProxy strategy is the action plan that the FNProxy needs in order to be stimulated by the change when the state of the FNProxy in FNQoS system changes in the life cycle. The default important state is the output value of the execution engine, but it also encourages designers to develop complex important states composed of multiple factors and the action plan that FNProxy must respond to.

The execution engine of the FNProxy is affected by the FNProxy's own characteristics, capability, FNProxy owner and other factors. Any FNProxy will respond to e1, e2 and en stimulation separately. The response action plan is a sub strategy (scheme) that is pre-placed in the FNProxy strategy base (FSB). The sub strategies are: scheme 1, scheme 2 and scheme n. As shown in Figure 4.

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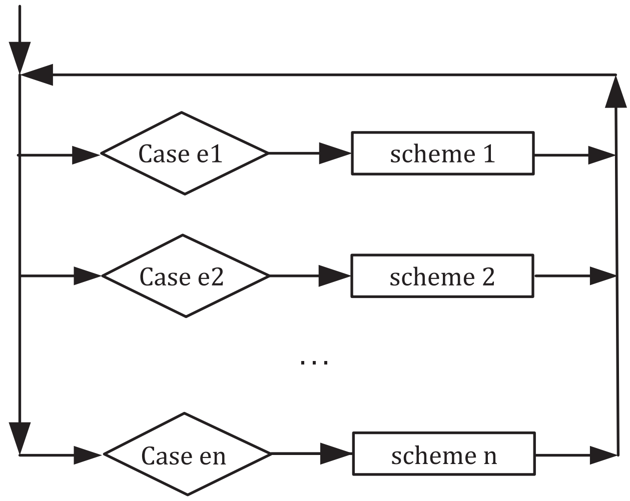

Figure 4 — Frame of strategy processing scheme in FNProxy

This FNProxy should be prepared by the designer in two ways: the first is the response measures sent by the FNProxy to the paired FNProxy according to the execution amount after the FNProxy completes the normal service execution. Pairing FNProxies treat their response value as their own perceived requirements.

On the other hand, when the FNProxy fails to reach a contract through negotiation, the FNProxy transits the unfinished service to another FNProxy selected according to its own situation.

4.2.6 Concept of the procedures in BFS

The concept of service effect of BFS can be understood as the sum of all the service procedures that are customized to solve various requirements based on the interaction between two FNProxies, i.e. the effect of FNQoS system is shown by all procedures, and each procedure includes a specific list of FNProxy sequential messages as follows:

FNQoS system = {Procedure list}

Procedure = {Sequential message list}

Although there are only two FNProxies in BFS, when the purpose and effect of the procedures supported by the two FNProxies are different, the interaction protocols between the two FNProxies are generally different. No matter what kind of purpose and effect of procedure in BFS, the protocol of FNProxy interaction in BFS should include three elements: the change of execution dynamic state of procedures (i.e. the so-called timing), the FPDU and its semantic change.

For example, in two procedures in BFS, such as the procedure of "start an FNProxy" and the procedure of "query an FNProxy", the FPDUstyle fields of the FPDU can be "M" (Management) and "O" (Operation) respectively. In addition, the FPDU of "start an FNProxy" procedure does not need extended fields, while the FPDU of "query an FNProxy" procedure needs extended fields (see special_FPDU in 5.6) to indicate that the query method is "INQUIRE", and the primitives and messages involved can be as follows:

Primitive:

Query (result, GN, Method)

Result: all methods and their functions of GN

GN: GoalNumber

Method: INQUIRE

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Message (Query)

{

"Method": "INQUIRE"

}

The semantics of the field "Method" is to use the public method "INQUIRE" of FNProxy GN. The public method can let the opposite FNProxy understand its own methods and capabilities.

After starting, the FNProxy can send a request message to query the other party at any time. In this way, all the methods and capabilities of the other party are known at any time.

Query (GN, INQUIRE);

There are four kinds of basic procedures in the BFS in Figure 5, Figure 6, Figure 7 and Figure 8. The primitives and messages that be involved are the following:

Procedure 1: The two FNProxies start individually

Primitive 1: Init (FNP owner's Initial value)

Message 1 (Init)

{

"Method": "initialize"

}

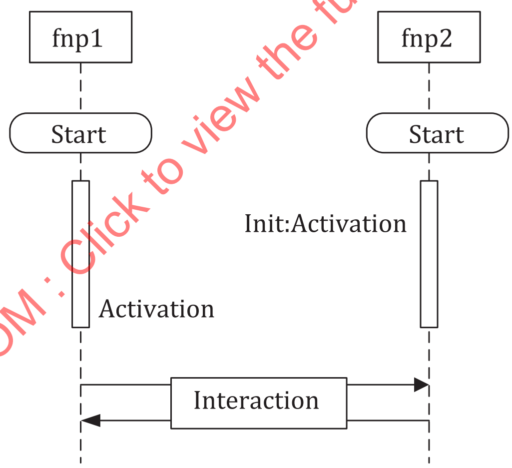

Figure 5 — Procedure started by two FNProxies independently

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Procedure 2: One awakens the other

Primitive 2:

INIT (FNP owner's Initial value)

WAKE_FNPROXY (SN, GN)

Message 2 (INIT, WAKE_FNPROXY)

{

"Method": "initialize", "request"

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}

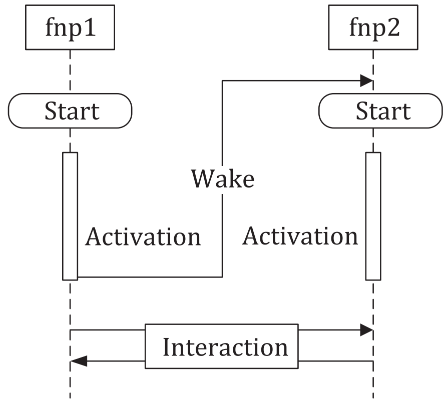

Figure 6 — Waking up the other party's procedureProcedure 3: Stopping FNProxy service from working

Primitive 3:

STOP (GN)

UPDATE (GN, SN)

Message 3 (STOP, UPDATE)

{

“Method”: “Stop”, “Update”

}

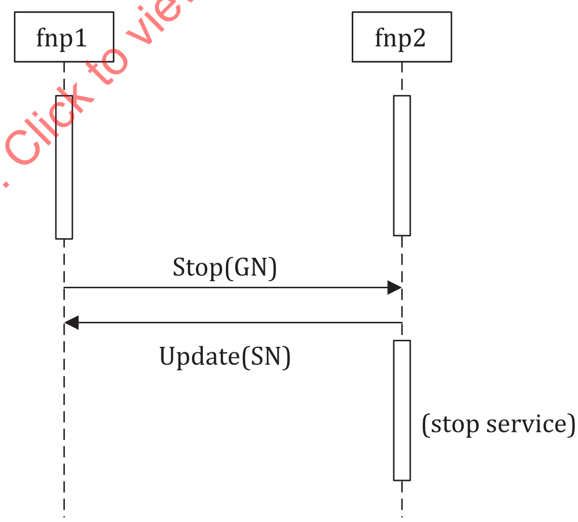

Figure 7 — Procedure of stopping FNProxy serviece

Procedure 4: Calculating harmony degree

Primitive 4:

HARMONY_DEGREE (result, FNP1, FNP2)

Result: Harmony degree

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FNP1: FNP1's information

FNP2: FNP2's information

Message 4 (HARMONY_DEGREE)

{

"Method": "Calculating"

}

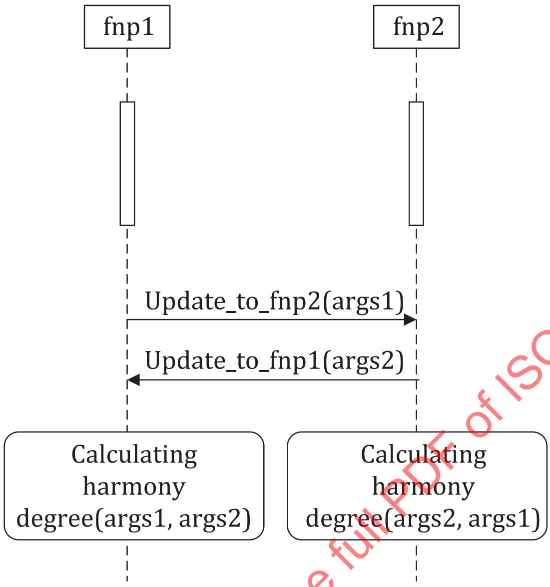

Figure 8 — Procedure of calculating the harmony value of SFS

4.2.7 Function invoke descriptions to domains of FNQoS system

The FNProxy should invoke the functions of the six functional domains (see ISO/IEC 21558-2) distributed in the FNQoS system. Generally, the functions of these three domains (management, operation and intelligent resources domain) are frequently-used functions supporting the FNQoS system in most cases. Some functions of these three domains are listed in Annex C for reference.

The FNProxy includes three engines that can work together: the perception engine, negotiation engine and the execution engine. Each engine of each FNProxy in the FNQoS system will use the functions in six domains in real time according to the FNProxy strategies and requirements.

In an FNQoS system, the cooperation mechanism among the engines in all FNProxies should be the same. When the three engines work, each engine in the FNProxy works according to the received information, combined with the FNProxy capabilities and strategies.

The intelligence level of FNProxies should depend on the intelligence level of the function of the intelligent resource domain. If the FNProxy can access the intelligent resources in the cloud through the application network (such as the Internet) realized by the communication domain function.

5 Protocol mechanisms in SFS

5.1 Description of SFS

The mechanism of multi FNProxy interaction protocol in BFS is based on the interaction mechanism between two FNProxies in SFS.

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SFS means that there are more than or equal to 3 FNProxies in the FNQoS system. Its characteristics are: there be multiple Bi-S pairs, and the FNProxy needs to report its information to the SFS.

When the SFS is composed of a mixture of FLMs as shown in Annex D, it is necessary to implement the link path between any two FNProxies. The FLMs in Annex D are used to service transition path fixed when service is not meet.

No matter how the SFS is implemented whether with central or distributed computation, designers should set the maximum number of FNPoxies in SFS by combining the characteristics of FNPoxies and calculating the memory size of nodes. In addition, the fixed FNProxy links of FLM should be used to achieve multi-FNProxy harmony (MFHR). As long as the value of MFHR is high, the service transition and information update time would be reduced in SFS.

5.2 Operations by using operator in SFS

In the SFS, the interaction mechanism becomes complicated due to the increase of the number of FNProxy pairs. In this case, the effect of improving the specific target achieved by the SFS will be better than that of the BFS. This constitutes the MFHR. MFHR is realized by multiple FNProxies with the help of those FLMs of FIB. FIB is a logical path or channel to realize the interactive exchange of information between FNProxies in SFS. As shown in Figure 9. The component software or hardware that can support the interaction of multiple FNProxies can be regarded as the bridge between related FNProxies. The software or hardware of this component is implemented based an FNProxy. If there is no link for these FNProxies, the FIB does not exist.

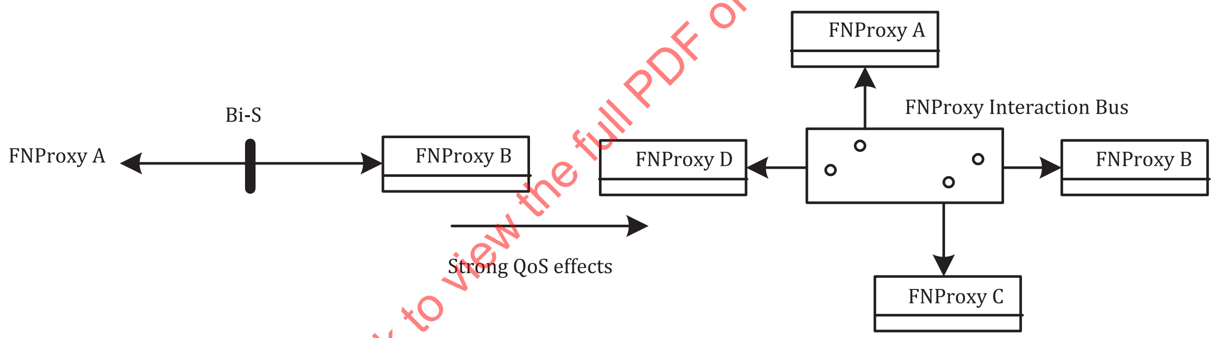

Figure 9 — Synthetic FNQoS system (SFS) with FIB

In order to facilitate the unification of the design and evaluation methods of various SFS, the links among FNProxies should be solidified into some special FLMs, as shown in Annex D.

The basis of multiple FNProxy interactions is that a single Bi-S can support a pair of FNProxies interactions and the Bi-S technical characteristics. Based on Bi-S, FNProxies in SFS can interact synchronously.

The analysis to FIB should at least include:

a) The dynamic/fixed interaction mechanism of FIB through FNProxies, i.e.,the interaction between FNProxies supported by multiple Bi-S pairs.

b) The method of FNProxy operating FIB, that should adopt modular idea and be realized by operators.

Analyse the universal interaction model or abstract operation symbol of calculation between FNProxies, as shown in Figure 10.

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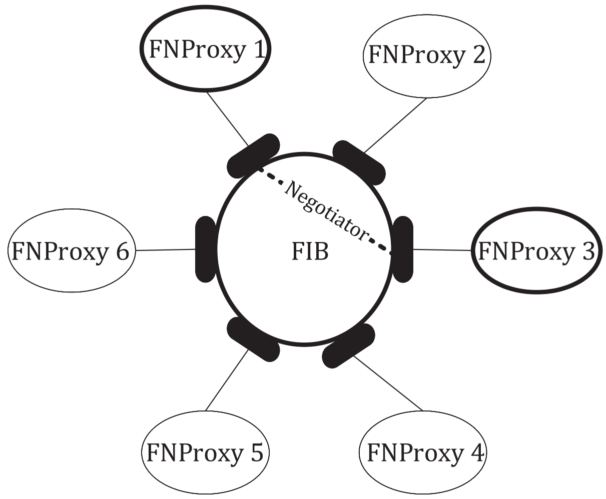

Figure 10 — FNProxy Interaction Bridge (FIB) among multi-FNProxies

For example, when negotiating between FNProxy 1 and FNProxy 3 in Figure 10, the following comprehensible formal mathematical operator (see ISO/IEC 21558-2) can be expressed (the designer can focus on developing operation process of the negotiator to reduce the complexity of the FNQoS system and its development costs):

(FNProxy 1) **Operator** (FNProxy 3) evolute to:

(FNProxy 1) **Negotiator** (FNProxy 3)

Similarly, in the FNQoS system, the binding, identification, registration, and Bi-S operations between any FNProxy A and any FNProxy B, even FNProxy A operating on itself can also be written as follows:

— (FNProxy A) Binder (FNProxy B)

— (FNProxy A) Identifier (FNProxy B)

— (FNProxy A) Registry (FNProxy B)

— (FNProxy A) Bi-S (FNProxy B)

— Self-Operator (FNProxy A)

The basic calculation meaning of operators Bi-S, binder, identifier and registry should be as follows:

— Bi-S: "(FNProxy A) Bi-S (FNProxy B)" refers to comparing the type and size between FNProxy A and FNProxy B respectively.

  For example, the result of the operator can be defined as the enumerator {(0, 0), (0, 1), (1, 0), (1, 1)}. When the formula "(FNProxy A) Bi-S (FNProxy B)" is operated, if the value of the formula is (0, 1), then it means that FNProxy A has no ability to serve FNProxy B, but FNProxy B has the ability to serve FNProxy A.

— "(FNProxy A) Binder (FNProxy B)" refers to both FNProxy A and FNProxy B have fixed service requirements, that is: they do not participate in the possible dynamic service transition activities in dynamic perception in the SFS.

— Identifier: (FNProxy A) Identifier (FNProxy B) refers to the technical process of identity determination between FNProxy A and FNProxy B. The calculation result of this operator is the current information and state of the two FNProxes if the identities of both parties are proved to be valid.

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— Registry: (FNProxy A) Registry (FNProxy B) refers to two parties registering their own information with each other in the case of no central FNProxy in SFS.

— Negotiator: (FNProxy A) Negotiator (FNProxy B) refers to the operator in which two FNProxes sign contracts with each other according to their own strategies after Bi-S operation in SFS.

— Self-Operator: Self-Operator (FNProxy A) refers to each FNProxy has its own process of variation.

The actual meaning and application effect of each operator can be customized according to the actual needs of the specific FNQoS system. BFSP is used in operator operation. See Annex B.

For Bi-S operators, such as for hybrid FLMs in FNQoS systems, the link path between any two FNProxies are implicitly established during the transition of FNProxy to the next FNProxy. Figure 11 shows the process of three consecutive transitions (A->B, B->C and C->D). Once the FNQoS system is running, any two FNProxies (for example, FNProxy A and FNProxy D) have implicitly realized the operation effect of three transitions in “A Bi-S D”. If necessary, special management software can be designed to extract the link path (A -> B -> C -> D) through multiple FNProxies in FLB.

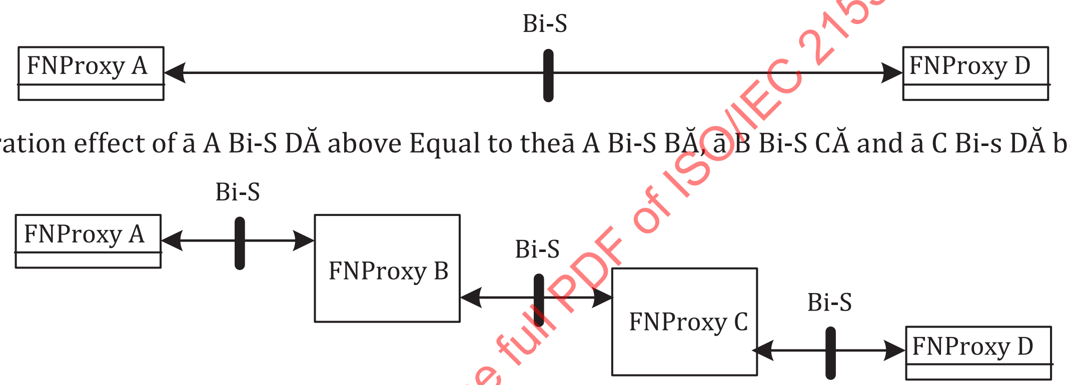

Figure 11 — Path of FIB linked by Bi-Ss under multi-FNProxy

5.3 Service transition by FNProxy strategy or FLM

5.3.1 Description of FLM for FIB

There are three FLMs specified: centralized, fully distributed, and hierarchical modes, which can choose to use when implementing a particular FNQoS system, as shown in Annex D. People can develop FLB technical documents based on but not limited to the three FLMs in Annex D that can be used by developers for their own FNQoS systems.

The SFS should record the necessary information of the FLM, including the type, structure, and the number of real-time FNProxies of the FLM, as well as the detailed log of each FNProxy's work. The log contents include any FNProxy in the FNQoS system, the necessary state information of all activities from activation (from start-FNQoS system to stop the FNQoS system). This state information should include service transition paths and changing history of requirements (services).

5.3.2 FNProxy strategy or FLM determining the service transition

Any FNProxy in SFS needs other FNProxy’s services on its FLM: Any FNProxy of the SFS in Figure 12 has the same work principle and steps. For example, FNProxy A1 includes the following steps: the perception engine P1 in FNProxy A1 processes the received real-time interference I1 and real-time preference RP1, then after the processing of negotiation engine N1 and execution engine E1, FNProxy A1 generates the requirement R1 of FNProxy A1 according to the execution value E1 and strategy S1. The meaning of FNProxy personification is: FNProxy A1's E1 means that FNProxy A1 has paid consumption or expense for E1; FNProxy A1 hopes to get a reward for R1.

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Which FNProxy in FLM serves the requirement R1 generated by FNProxy A1 in SFS depends not only on the above steps of generating R1, but also on the FLM adopted by FNQoS system.

As shown in the dotted line with arrow on the left from R1 to P2 in Figure 12, the type of requirement R1 is consistent with the type of capability of FNProxy A2, i.e. FNProxy A2 serves FNProxy A1. Since P1 of FNProxy A1 is R2 of FNProxy A2, both FNProxy A2 and FNProxy A1 serve each other. This constitutes the Bi-S case. The service effect or harmony degree between FNProxy A2 and FNProxy A1 with Bi-S is higher than that without Bi-S.

As shown in the dotted line with an arrow on the right from R1 to Pn in Figure 12, FNProxy An serves FNProxy A1. Because of service transition, the number of FNProxies in FNQoS system is increased from 2 to 3. FNProxy An is an FNProxy in FNProxy link graph of FLM. The type of the capability of FNProxy has been set by the designer in advance to be consistent with the type of requirement R1 at this time. In other words, FNProxy An is preset to serve FNProxy A1 in advance.

The implementation mechanism of FNProxy link of FLM is not specified.

Whether the FNProxy An in SFS can serve the requirements generated by FNProxy A1 depends on the uncertainty of the calculation results of the internal dynamic operation steps of FNProxy A1 and the FNProxy linking mechanism of FLM adopted by FNProxy An. The dynamic working process of these mechanisms, together with their FPDU fields and field contents, supports the protocol of interaction between FNProxies.

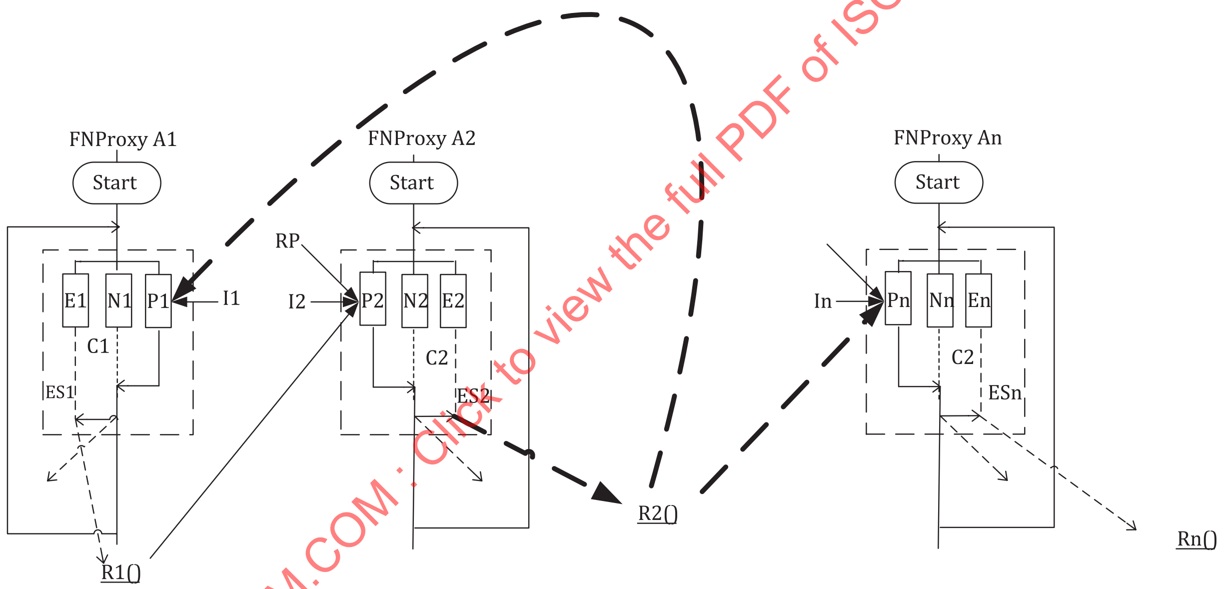

Figure 12 — FNProxy strategy or FLM determining the service transition

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5.4 Sequence diagram overview related to SFS

5.4.1 General description of sequence diagram to SFS

From the perspective of FNProxy owner, observer of SFS and other roles, this subclause expounds some basic sequence technologies that can be involved in multi-FNProxy interaction. This can be used as a reference to design appropriate FIB details and to improve the comprehensive effect of the SFS. Multi SFSes are referenced in Annex E.

Figure 13 shows the sequence diagram related to the SFS. Figure 13 shows the sequence overview diagrams of related FNProxies observed from the perspective of owner of FNProxy fnp-1 during the operation of SFS.

The development of a unified FNProxy naming method is recommended.

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Although the whole picture of the interaction of the protocol mechanism of all FNProxies is not seen, it is understood from the perspective of one FNProxy.

5.4.2 Main elements in the sequence diagram

5.4.2.1 Timing

In SFS, FNProxy fnp-1, fnp-2, fnp-n and fnp-m stimulate each other according to the link mode of predeterminate FLM they use to form this SFS with predeterminate dynamic characteristics. It also includes the dynamic characteristics stimulated by the FNProxy's predetermined strategy.

The sequence diagram overview of SFS shown in Figure 13 mainly shows the activity relationship with other FNProxies from the perspective of working process of FNProxy fnp-1.

a) The start of fnp-1 includes the personalized start of perception engine, negotiation engine and execution engine.

b) The three engines then repeatedly perform the tasks in sequence. When the perceived requirement type is a new type, it will be transited to FNProxy fnp-m; if it is not a new type, but fnp-1 is not capable enough, it will be transited to fnp-n; if it is within the scope of fnp-1, it will be executed by fnp-1.

When the FNProxy fnp-1 is executed, which fnp-1 should be asked for requirements is related to the FLM of the SFS and the execution strategy ES1 in Figure 12. By default, fnp-1 requires FLM to transit to a fixed FNProxy. However, if the execution strategy ES1 of fnp-1 is different from FLM, it is possible to transit to FLM’s other FNProxy.

If fnp-1 perceives that the requirement comes from FNProxy fnp-2, and the execution strategy ES1 of fnp-1 requires that the FNProxy serving fnp-1 is also fnp-2 (i.e. the requirement of fnp-2 comes from fnp-1), then the FHR value of SFS composed of FNProxy fnp-1 and fnp-2 can be very high, as shown in Annex G.

The three engines are closely related to FNProxy fnp-1. The three engines working independently are closely combined to form FNProxy fnp-1.

The roles that interact with the SFS are: fnp-1 owner user, SFS observer user and party of "requirement and environment change". These roles can interact directly with the SFS.

5.4.2.2 Transition strategy of negotiation

When requirements are a new type, either it will not be able to reach a contract, or it can transit to FNProxy fnp-m. This depends on the negotiation strategy of the FNProxy.

When the requirements are not of a new type and the contract/capability is insufficient, then it either will not be able to reach a contract, or it can transit to FNProxy fnp-n. This depends on the negotiation strategy of the FNProxy.

5.4.2.3 Startup of the SFS itself

The third party (observation of SFS) sends the message to start SFS.

The owner of fnp-1 sends the start message and starts its three engines. The owner of other FNProxies also sends out to start their own FNProxies.

5.4.2.4 Engine operation

For the sake of realize the normal operation of FNProxy fnp-1, the perception engine, negotiation engine and execution engine work in sequence.

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5.4.2.5 SFS output contribution

FNProxy fnp-1 reports the information data of the current engines to the observer when it runs repeatedly. At the same time, SFS calculates the value of contribution rate of each FNProxy in real time (see Annex A).

5.4.2.6 SFS stop operation

The SFS can stop the operation only when SFS observer or FNProxy fnp-1 sends a message to terminate the operation.

5.5 Narrative of AI dynamically enabling interaction

5.5.1 General

The FNQoS system has the dynamic property of an AI enabling effect. It is caused by the following two aspects:

a) when the FNProxy link topology of FLM changes over time, the comprehensive effect of FNQoS system will change dynamically;

b) the dynamic adaptive process of FNQoS system caused by the dynamic perception of engine of each FNProxy.

The a) be addressed by SDO setting relevant technical documents, while the b) be addressed in combination with practical scenarios.

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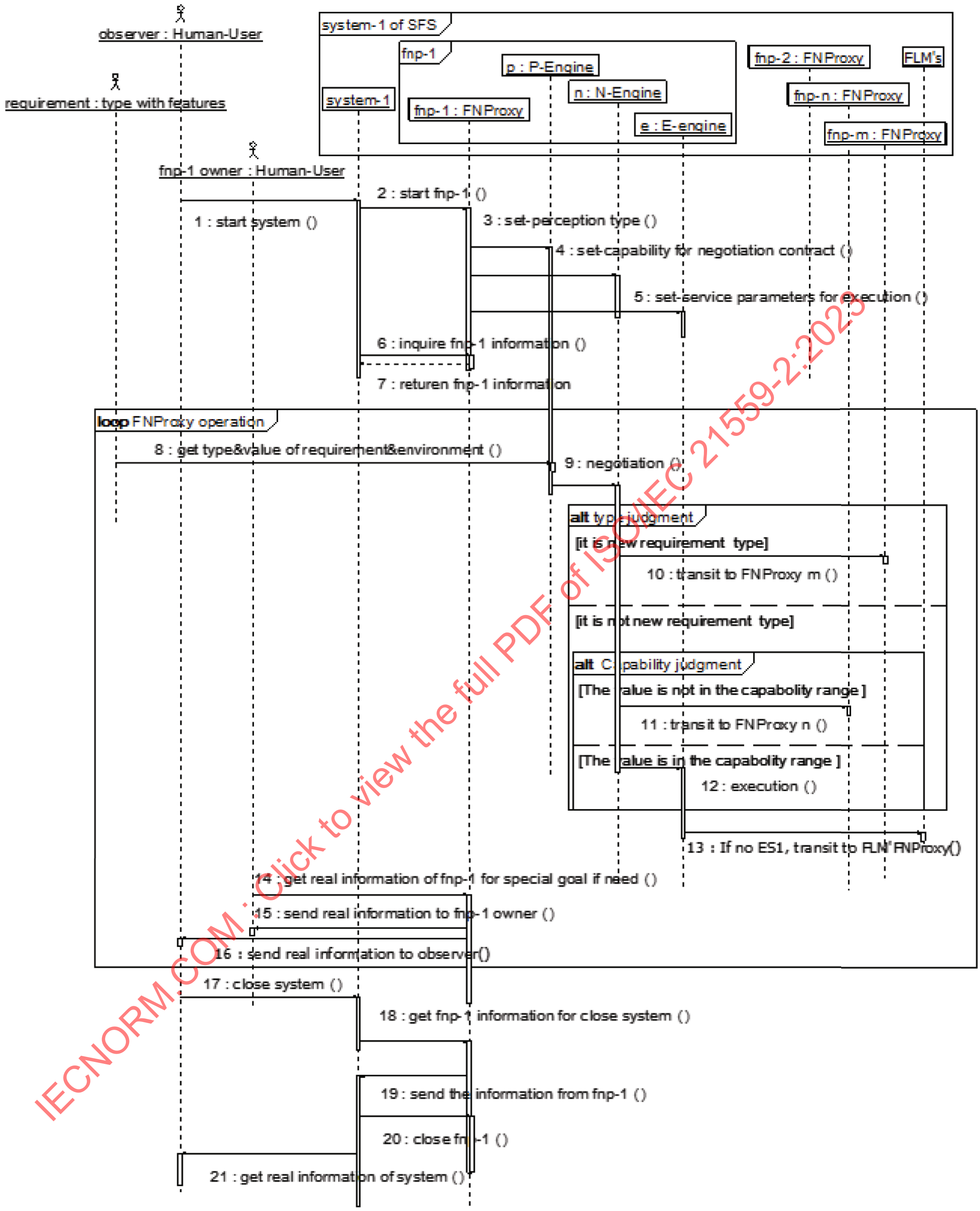

Figure 13 — Sequence overview diagram from fnp-1 aspect of SFS

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5.5.2 Dynamism caused by FNProxy link topology change

This is better suited to developing dynamic AI enablement effects for point-to-point (end-to-end) communication when there are only a pair of FNProxies of simple link topologies.

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When it is an interactive mechanism among multiple FNProxies, it is more applicable to base AI on a wide range of interconnection system applications. Using AIEN method can develop more new network forms, even dynamic semantic networking based on semantics.

The dynamic effect of FNProxy link in FNQoS system is aimed at MFHR, which is similar to the dynamic interaction effect of social crowd. See Annex F.

5.5.3 Dynamism by driving the external environment

The FNProxy perceiving the external dynamism of environment triggers the dynamism of the FNQoS system. That include:

a) Transition of FNProxy service not only changes the number of FNProxy links in the FNQoS system, but also brings dynamic changes to the link topology of FLM.

b) When FNProxy senses that the context changes the FPDU field of FNProxy in FLM in real time, it should form a dynamic process according to its own strategy. The result of processing can lead to dynamic changes of dynamic links, and corresponding processing methods should be reserved for FNQoS.

In the FNQoS system, the AI dynamically enabling interaction makes it possible for some FNProxies to be served multiple times. FNProxies in the FNQoS system are required to participate in multiple services, so that the FNQoS system is trying to achieve the best possible service effect. See Annex G.

5.6 General framework of SFSP

This subclause resolves the 12 FNQoS requirements listed in the second half of ISO/IEC 21558-2:2023, Figure 7 (titled architectural model and supported FN requirements) and provides a unified framework for FNProxy-based FNQoS protocol generation.

By extracting the corresponding FNProxes from the FNQoS requirements and referring to the framework method, the problem of customization of QoS protocols in FNs and traditional networks can be solved.

The general protocol framework of FNQoS requirements includes the following aspects:

— the name of FNQoS system;

— the name of a Procedure in the FNQoS system;

— the name table of FNProxes participating in the interaction in the Procedure;

— the protocol name of FNProxy interaction;

— the special fields required by the FNQoS protocol;

— the meaning of each field;

— the time sequence generated by the method function of the domain or a group of operators.

```
Framework of SFSP
{
FNQoS system_name;
Procedure_Name;
Names_of_FNProxies_involved;
Protocol_Name;
Special_FPDU;
```

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Semantics of Special_FPDU;

Timing based on special_FPDU;

};

This FNQoS protocol framework implies the following:

— the FNQoS system contains multiple Procedures;

— each Procedure contains multiple FNProxy interactions;

— the different interaction forms of these FNProxy constitute the special protocol of interaction effect.

FNQoS protocol refers to the synthesis of these special protocols. The effect of FNQoS system refers to the comprehensive effect of these special protocols in work.

Among them, special_ FPDU is an extension of FPDU field for FNQoS requirements.

Special_FPDU

{

FPDU;

Feature_Field_List; / feature field list of Future Network requirements to improve QoS.

}

The feature field list is extracted from the following aspects by the designer's experience. Namely:

Feature_Field_List = {FNQoS requirement name, list of key technology problems to be solved, list of working environment scope, list of objectives, list of working parameters}.

The reference method steps of customizing the protocol to improve FNQoS for special requirements are shown in the Figure 14.

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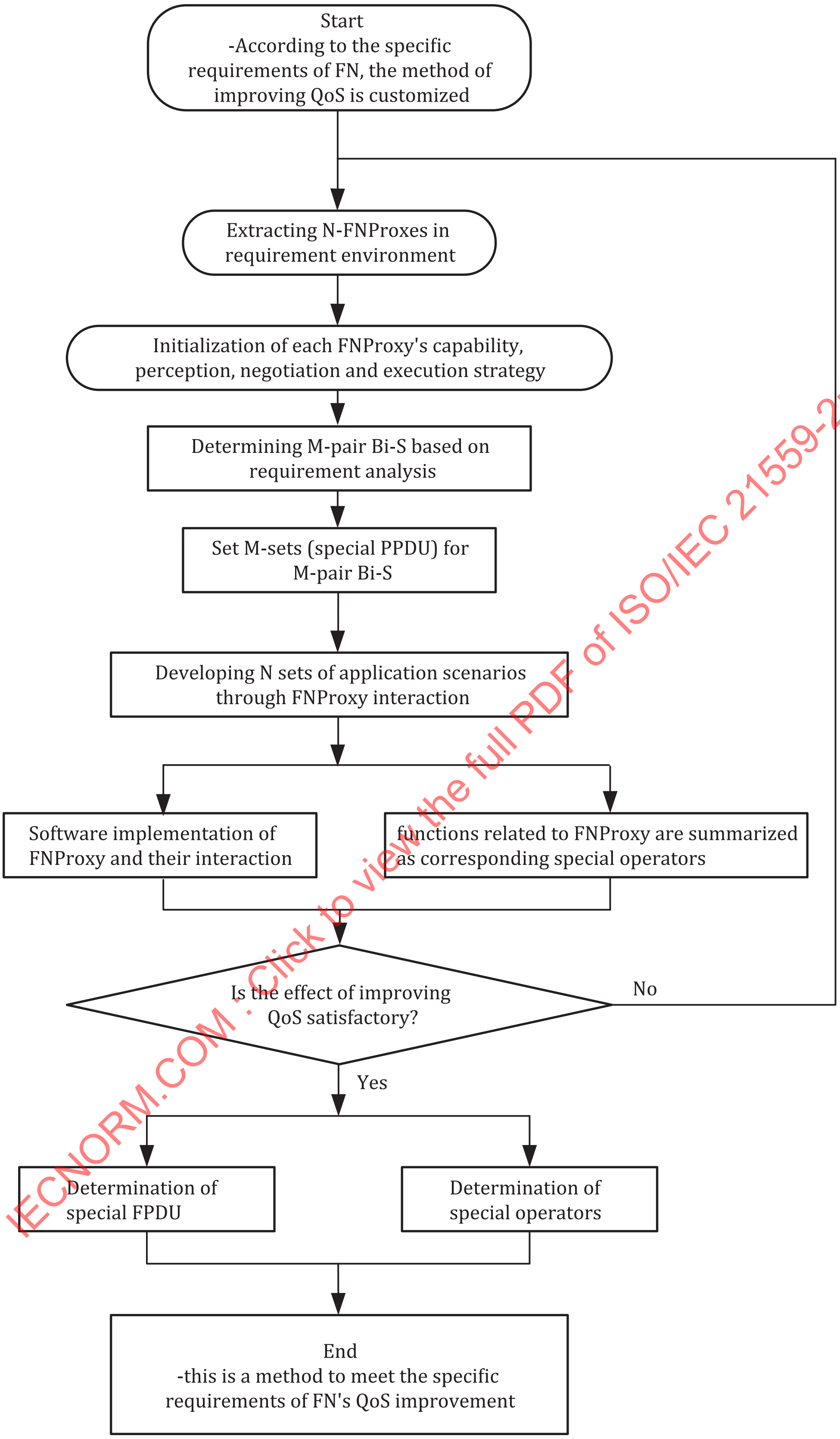

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Key

N The number of FNProxies in FNQoS system. Each FNProxy has the ability to provide services for specific FNProxy, and also has the ability to put forward requirements to other FNProxy.

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M The number of pairs of FNProxies serving each other in N FNProxies. These pairs of FNProxies will be considered to form the FLM of the SFS. When N is 2, SFS becomes BFS.

Figure 14 — Methods of improving the QoS of FN by customization of requirements

The method described in Figure 14 is not limited to more than 12 FNQoS requirements mentioned in ISO/IEC TR 29181-8, but can follow this general FNQoS protocol framework. See Annex H for details of the generation process of FNQoS protocol of each FN requirement.

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Annex A
(informative)

Representation reference of FNProxy collaboration effects

A.1 General

This annex includes two reference methods of evaluation calculation of FNProxy collaboration effects to the FNQoS system. The former can be used for rapid deployment, while the latter needs to adjust the impact factor value according to the characteristics of the FNQoS system.

A.2 Reference calculation method based on real time contribution rate

Definition

The *Vect* represents the vector formed by the state of each FNProxy of all FNProxies in the FNQoS system. The value of the state can usually be the service, capability, attribution, parameter of FNProxy.

That is:

$$Vect_{FN\,\mathrm{Pr}oxy_x} = \beta_x, x = 1,2,3,\cdots$$

$$\beta_x = (a_{x1}, a_{x2}, a_{x3}, \cdots, a_{xn})^{\mathrm{T}}, n = 1,2,3,\cdots$$

where

$Vect_{FN\,\mathrm{Pr}oxy_x}$	is a vector formed by the state of each FNProxy in the FNQoS system. The $Vect_{FN\,\mathrm{Pr}oxy_x}$ can also can be indicated as β_x;
x	is the sequence number $(1,2,3,\cdots)$ of FNProxy in FNQoS system;
a_{xi}	is the state value of the x-th FNProxy at time i.

Here, the ellipsis indicates that there be multiple FNProxies in an FNQoS system, every FNProxy has multiple dimensions.

a). Basic FNQoS system (BFS)

Therer are interactions between two FNProxies in BFS. In case of: each providing only one service.

Definition 1The state value of two FNProxies at the initial time 0 is:

$$\beta x\_s0 = (a_{x1\_s0}, a_{x2\_s0})^T$$

In order to facilitate, here the $(a_{x1\_s0}, a_{x2\_s0})^T$ can be understood as FNProxy capability value in practical application.

Definition 2

The state value of two FNProxies at time i is two elements of vector. State value at state i $(a_{x1\_si}, a_{x2\_si})^T$ can be understood as real services.

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That is

$$\beta x\_si = (a_{x1\_si}, a_{x2\_si})^T$$

So that, each FNProxy's contribution rate and weight to the BFS at time I can be expressed as followings.

Contribution rate of FNProxy 1 to the BFS at time i:

$$hf_{x1} = \frac{\| a_{x1\_s0} - a_{x1\_si} \|}{\| a_{x1\_s0} \|}$$

Contribution rate of FNProxy 2 to the BFS at time i:

$$hf_{x2} = \frac{\| a_{x2\_s0} - a_{x2\_si} \|}{\| a_{x2\_s0} \|}$$

Contribution rate of FNProxy 1 to the BFS at time i related to the weight:

$$whf_{x1} = \frac{\| a_{x1\_s0} - a_{x1\_si} \|}{\sum_{j=1}^{2} \| a_{xj\_s0} - axj\_si \|}$$

Contribution rate of FNProxy 2 to the BFS at time i related to the weight:

$$whf_{x2} = \frac{\| a_{x2\_s0} - a_{x2\_si} \|}{\sum_{j=1}^{2} \| a_{xj\_s0} - axj\_si \|}$$

Harmony value/ degree of the BFS at time i:

$$H = \sum_{j=1}^{2} whf_{xj} * hf_{xj}$$

b). Synthetic FNQoS

There are interactions among n FNProxies in SFS, in case of each providing only one service.

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The state information of FNProxy in initial time (recording FNProxy capability):

$$\beta x\_s0 = (a_{x1\_s0}, a_{x2\_s0}, ..., a_{xn\_s0})^T$$

FNProxy state information at time i:

$$\beta x\_si = (a_{x1\_si}, a_{x2\_si}, ..., a_{xn\_si})^T$$

The contribution rate of FNProxy j to the SFS at time i:

$$hf_{xj} = \frac{\| a_{xj\_s0} - a_{xj\_si} \|}{\| a_{xj\_s0} \|}$$

The contribution rate of FNProxy j to the SFS at time i related to the weights:

$$whf_{xj} = \frac{\| a_{xj\_s0} - a_{xj\_si} \|}{\sum_{j=1}^{n} \| a_{xj\_s0} - axj\_si \|}$$

The harmony value/ degree of the SFS at time i is:

$$H = \sum_{j=1}^{n} whf_{xj} * hf_{xj}$$

A.3 Reference method based on statistics and dimension weight of the FNProxy

According to the actual requirements of information systems in different fields, developers can customize FNQoS system based on the harmonious effect of FNProxy interaction. Since the number of FNProxies extracted from different fields, the content of FNProxies, and the interaction protocol will not be the same, the impact factor of the harmony effect should be set according to the application scenario. When the the number of success negotiations and transitions is different during the interaction, the correction coefficient is further set for the impact factor, so that the harmony measurement of the field FNQoS system can be more consistent with the requirements.

b) The impact factor of the FNQoS system during FNProxy interaction

Definition: impact factor. The impact factor of FNQoS is called as IQS.

That is:

$$\frac{N_1}{N_2 k N_3} \alpha\gamma \, (N_2 > 0, N_3 > 0)$$

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where

$\frac{N_1}{N_2 k N_3} \alpha\gamma$	is impact factor according the various field;
N_1	is in FNQoS System, FNProxy interact dynamically with each other, the number of successful negotiations;
N_2	is the number of FNProxies in the FNQoS system;
N_3	is the number of FNProxy service transitions in FNQoS system;

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N_4 is in FNQoS system, the number of successful negotiations that can be reached after only one negotiation;

k is correction factor of FNProxy service transitions times in FNQoS System;

γ is $\gamma = \frac{N_4}{N_2}$;

It is called correction coefficient, it can have different values according to the actual situation in FNQoS system;

θ is the maximum value of complexity of FNProxy linking toplogy environment in FNQoS system for a specific field based on statistics and experiments;

α is value of complexity of FNProxy linking toplogy environment in FNQoS system. When the FNProxy linking toplogy environment is difficult to reach a contract, it can take any value greater than zero and less than θ, that is $0 < \alpha \leq \theta$; When the FNProxy linking toplogy environment is so ideal that it is easy to reach a contract, it can take any value greater than θ, that is $\alpha > \theta$.

When $N_2 = 0$, the impact factor of FNQoS is 0.

When $N_3 = 0$, it indicates that no FNProxy service transitions occurred, the impact factor of FNQoS is

$$\frac{N_1}{N_2}\alpha\gamma(N_2 > 0)$$

b). The quantized value of FNQoS

The quantized value of FNQoS is called the degree of harmony, that is

$$IQS\sum_{x=1}^{n}\frac{w_{hf_x}}{\sum_{x=1}^{n}w_{hf_x}}hf_x, x = 1,2,3,\cdots,n$$

where x is the sequence number of FNProxy in FNQoS system.

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β_{x_si} : The specific state vector of FNProxy x in state i, $i = 1, 2, 3, \cdots$

$$\beta_{x\_si} = \left(a_{x1\_si}, a_{x2\_si}, a_{x3\_si}, a_{x4\_si}, a_{x5\_si}, a_{x6\_si}, \cdots, a_{xn\_si}\right)^{\mathrm{T}}$$

β_{x_sj} : The specific state vector of FNProxy x in state j, $j = 1, 2, 3, \cdots$

$$\beta_{x\_sj} = \left(a_{x1\_sj}, a_{x2\_sj}, a_{x3\_sj}, a_{x4\_sj}, a_{x5\_sj}, a_{x6\_sj}, \cdots, a_{xn\_sj}\right)^{\mathrm{T}}$$

Weight matrix

$$\begin{pmatrix} w_1 & 0 & 0 & 0 & 0 & 0 & \cdots & 0 \\ 0 & w_2 & 0 & 0 & 0 & 0 & \cdots & 0 \\ 0 & 0 & w_3 & 0 & 0 & 0 & \cdots & 0 \\ 0 & 0 & 0 & w_4 & 0 & 0 & \cdots & 0 \\ 0 & 0 & 0 & 0 & w_5 & 0 & \cdots & 0 \\ 0 & 0 & 0 & 0 & 0 & w_6 & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & 0 & 0 & 0 & \cdots & w_n \end{pmatrix}$$

where, w_1, w_2, w_3, w_4, w_5, w_6, $\cdots$, w_n represent the weight of each dimension of the FNProxy vector respectively, their values depend on the FNQoS system situation.

$\left\| W\beta_{x\_si} - W\beta_{x\_sj} \right\|$ is the size of state transition vector of the FNProxy x, to some extent, it can reflect the extent of FNProxy service transitions, the size of it is proportional to the FNQoS.

$\sum_{x=1}^{n} \left\| W\beta_{x\_si} - W\beta_{x\_sj} \right\|$ is the sum of all FNProxy services.

The contribution rate of FNProxy x in FNQoS system is

$$hf_x = \frac{\left\| W\beta_{x\_si} - W\beta_{x\_sj} \right\|}{\sum_{x=1}^{n} \left\| W\beta_{x\_si} - W\beta_{x\_sj} \right\|}$$

In FNQoS system, the contribution rate of each FNProxy can be expressed as hf_1, hf_2, hf_3, $\cdots$, hf_n

$$w_{hf_x} = \frac{hf_x}{\sum_{x=1}^{n} hf_x}$$

where w_{hf_x} represents the weight of FNProxy x contribution rate

Normalization of FNProxy x weight is $\frac{w_{hf_x}}{\sum_{x=1}^{n} w_{hf_x}}$.

The contribution rate of all FNProxies in FNQoS system is $\sum_{x=1}^{n} \frac{w_{hf_x}}{\sum_{x=1}^{n} w_{hf_x}} hf_x$.

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Annex B
(informative)

Bi-S operator Example between two FNProxies with C++

B.1 General

The following codes follow the programming languages in ISO/IEC 14882. It describes how to design the Bi-S operator for the FNQoS system to achieve C++ polymorphic operations of abstract interfaces under different QoS FNProxies. Polymorphic operations can be used to the main process of negotiation, binding, identification, registration and administration of FNProxy pairs with Bi-S.

B.2 FNProxy virtual function for overload

```
class FNProxy { virtual interface(); }
```

B.3 FNProxy_A and FNProxy_B inherits from FNProxy

```
class FNProxy_A: public FNProxy

{/*overload

      virtual interface () { /*FNProxy_A's all methods };

};

class FNProxy_B: public FNProxy

{/* overload

      virtual interface (){/*FNProxy_B's all methods };

};
```

B.4 Maintaining the globe Bi-S operator in FNQoS system

The following functions can be used to the main process of negotiating, binding, identification, registration, and management of FNProxy pairs with Bi-S.

```
void Bi-S(FNProxy *a, FNProxy *b)

      {

      a->interface();/*

      b->interface();/*

      function(); /*negotiating, binding, identification, registration, and management of
      Bi-S pairs.

      }
```

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```
        /* start FNQoS system
void main (){
        FNProxy_A a; FNProxy_B b;
        FNProxy *p_a=&a, *p_b=&b;
        Bi-S(p_a, p_b);
        }
```

Figure B.1 shows the reference flow of an FNProxy that adopt the Bi-S operator when it is newly registered into the FNQoS system and makes contributions to the FNQoS comprehensive behavior effects.

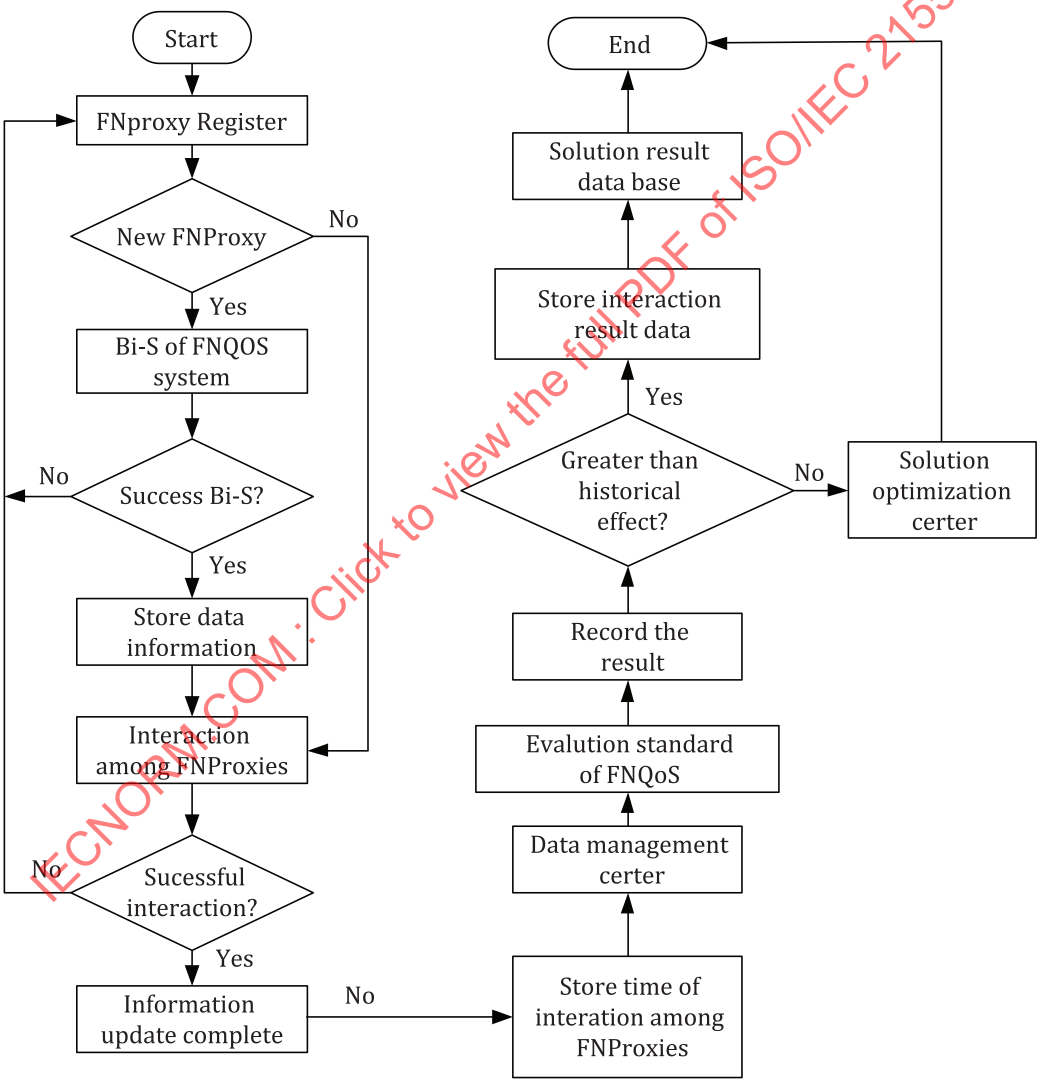

Figure B.1 — Flow chart of FNProxy registering in FNQoS system

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Annex C
(informative)

Methods for the domains

Any FNProxy should have:

a) Both required and public methods: The invoked INQUIRE method. Other methods can be set to either be required or optional (Required |Optional), depending on the situation.

b) Requirement type base: can be stored locally or in the associated cloud server that can be remotely accessed by the FNProxy.

c). Algorithm base: the algorithm base can be used by three engines. At the very least, it can be used for the analysis and processing of requirement data types by FNProxy perception engines.

The method and function description in Table C.1 can be used when designing specific perception, negotiation and execution engines.

The functions of FNProxy domain are designed and placed in each FNProxy. Table C.1 shows the general functions of the other five domains.

Table C.1 — Reference methods for the FNProxy related domains

Method name[f]	Description	Possible domains				
INQUIRE	Inquire FNProxy information. The information includes service FNProxy's all methods and capability and so on. This method is Open, Required to all FNProxies.	M[a]	U[b]	C[c]	O[d]	I[e]
GET-REAL-INFORMATION	Get the real IQS information from FNQoS system	√			√	√
SET-INITIAL TYPE	Set initial type of perception	√	√		√	
SET-CAPABILITY	Set FNProxy capability for service	√	√			
SET-EXECUTION	Set service parameters for execution	√	√			
Get-SEPARABILITY-MEASURE	Get Classification separability measure of requirement type	√			√	√
PERCEPTION TYPE&VALUE	Get type&value of requirement | environment	√			√	√
TRANSIT-TO-FNPm	Transit to fnp-m FNProxy which there is new type	√		√	√	√
NEGOTIATION	Negotiate with fnp-x	√		√	√	√
TRANSIT TO FNPn	Transit to fnp-n FNProxy that It can complete the service			√	√	√

[a] M: management

[b] U: user

[c] C: communication

[d] O: operation

[e] I: intelligence resource

[f] The method names listed below be selected and used by designers in making of specific FNQoS systems based on the scenario.

Add-Service, Remove-Service, Add-Requirement, Remove-Requirement, Edit-Requirement, Add-Strategy, Remove-Strategy, Edit-Strategy, Get-Services, Get-Requirements, Get-Negotiations, Get-Execution, Update-Value, Get-Knowledge, Set-Knowledge, Set-Strategy, Set-Capability, Inference, Get-Negotiations-Nums, Get-Run-Strategy-Nums, Get- Capability, Get-Num-Transiton, Get-Harmony-Degree, Get- Capability -Change-Num, Calculate-Data-FNQoS, Storage-type-Date, Data-AI-Analysis.

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Table C.1 *(continued)*

Method name[f]	Description	Possible domains				
UPDATE CONTRACT& EXECU-TION	Update fnp-x contract & execution information	√		√	√	√
UPDATE FNP1	Update fnp-1 information from FNQoS system	√			√	√

[a] M: management

[b] U: user

[c] C: communication

[d] O: operation

[e] I: intelligence resource

[f] The method names listed below be selected and used by designers in making of specific FNQoS systems based on the scenario.

Add-Service, Remove-Service, Add-Requirement, Remove-Requirement, Edit-Requirement, Add-Strategy, Remove-Strategy, Edit-Strategy, Get-Services, Get-Requirements, Get-Negotiations, Get-Execution, Update-Value, Get-Knowledge, Set-Knowledge, Set-Strategy, Set-Capability, Inference, Get-Negotiations-Nums, Get-Run-Strategy-Nums, Get- Capability, Get-Num-Transiton, Get-Harmony-Degree, Get- Capability -Change-Num, Calculate-Data-FNQoS, Storage-type-Date, Data-AI-Analysis.

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Annex D
(informative)

FNProxy Link Modes (FLMs) for SFS

D.1 General

Those FLMs in Figure D.1, Figure D.2 and Figure D.3 can be referenced, also the mix of them can be used as FNProxy linking with Bi-S in SFS.

No matter which FLM is suitable for SFS, the working strategies of each FNProxy's engines in FLM are determined by the goal of FNQoS system. When FNQoS works, although the FNProxy link complies with FLM, each FNProxy can be set to corresponding working (perception, negotiation and execution) strategies when it is started.

D.2 Centralized FLM

The centralized FLM is equivalent to FIB and shown in Figure D.1.

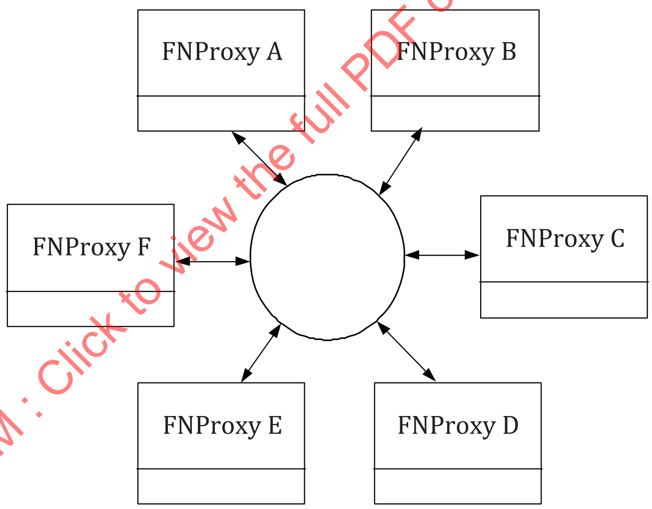

Figure D.1 — Concentrative FLM

D.3 Full distributed FLM

The full distribute FLM is shown in Figure D.2.

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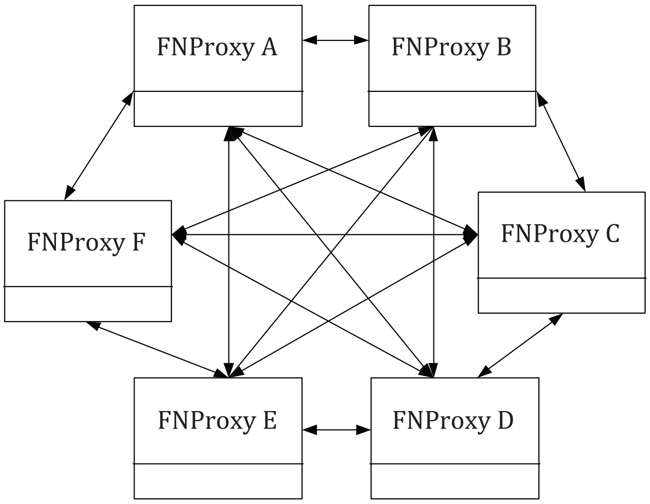

Figure D.2 — Full distributed FLM

D.4 Hierarchical FLM

The hierarchical FLM is shown in Figure D.3.

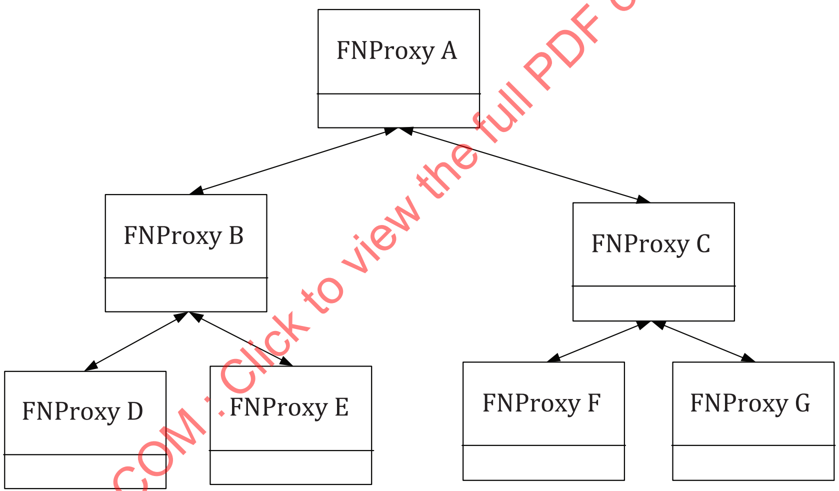

Figure D.3 — Hierarchical FLM

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