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**Title: DetNet solution #3 update and conclusions**

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*Abstract of the contribution: We address the open questions in Solution #3, discuss the main outstanding issues in the DetNet study and propose a conclusion.*

# Update of Solution #3

Solution #3 has two FFS items; we propose to add further clarifications as shown in the proposal below.

# Discussion of the main DetNet outstanding questions

The solutions in the DetNet study TR 23.700-46 have a lot of overlap between them, but there are also differences and open issues. We consider the main open questions and propose a resolution for them.

**Which protocol is used between 5GS and DetNet controller?**

The IETF DetNet work aims to provide deterministic service on the IP layer, so that a number of underlying technologies, including the 5G system, can make use of the DetNet framework. The DetNet solution uses IETF protocols for this. To make the 5G integration of DetNet useful, we need to use IETF protocols as described for DetNet for the signalling between 5GS and the DetNet controller.

The DetNet framework uses YANG models which can be carried over Netconf or Restconf. It is proposed that the 5GS integration of DetNet follows the same approach and uses YANG models carried over Netconf or Restconf between the TSCTSF and the DetNet controller. We s uggest leaving it to the needs of the actual deployments whether Netconf or Restconf is chosen according to the market demand.

*Conclusion 1: YANG models over Netconf or Restconf are used between the TSCTSF and the DetNet controller.*

**Is an optional NEF supported between TSCTSF and DetNet controller?**

In the TSN integration case, there is no NEF used in the signalling from the CNC and the TSN AF, since the TSN AF as well as the CNC are considered trusted entities, and the operator has the necessary business agreements in place. Similarly, the DetNet integration can be supported with a trusted DetNet controller without the need to insert additional entity such as the NEF into the signalling path. Note that the DetNet controller is capable of influencing the QoS for the whole network, not just for a single UE as in the case of an AF, and that is something for which a trusted relationship with the operator can be assumed. Note also that the TSCTSF can also perform a verification of the requests from the DetNet controller and can reject the requests which are deemed unacceptable as per operator policy.

Involving the NEF in the signalling path between TSCTSF and DetNet controller is not easy from the signalling protocol point of view. According to Conclusion 1, an IETF protocol (Restconf or Netconf) is used to carry YANG models, but these protocols do not have a standardized way to insert a new entity acting as a proxy into the signalling path. Further, 3GPP normally uses a 3GPP defined signalling between two 3GPP entities such as the NEF and the TSCTSF, but in this case we would need to either use an IETF protocol or perform protocol conversion which is unnecessarily complex. Overall, the involvement of the NEF into the signalling would require a significant protocol extension of the IETF signalling framework, which is beyond the scope of the current study, and the need for such complexity is not justified.

In deployments where the security functions of NEF would be desirable, it can be considered to include relevant security functions in the TSCTSF. As described in 23.501 section 6.2.5.0 concerning NEF functionality, the NEF may authenticate and authorize and assist in throttling the Application Functions. Similar to the NEF, the TSCTSF may also perform the authentication and authorization of the signalling with the DetNet controller, and if the risk of excessive signalling arises, the TSCTSF may also help to throttle the signalling. The need for such functionality can be a deployment decision.

*Conclusion 2: 3GPP does not standardize any signalling mechanism to include the NEF into the signalling path between the TSCTSF and the DetNet controller. If NEF functionality is desired, the relevant functions such as the authentication, authorization and potential throttling of signalling can be achieved by including such functionality in the TSCTSF depending on the needs of the given deployment.*

**Which entity collects and provides exposure information to the DetNet controller?**

From the point of view of the DetNet controller, the 5GS acts as a router, and the management interface to the 5GS router has to have a single termination point, which should be the TSCTSF according to the assumptions of the study. There cannot be a different termination point for exposure (KI#1) and a different termination point for the parameter mapping (KI#2). The existing Rel-17 TSC procedures can be re-used to collect information from the UPF/NW-TT and the SMF, adding information elements as needed.

*Conclusion 3: The TSCTSF terminates the interface towards the DetNet controller. The TSCTSF collects and provides exposure information to the DetNet controller. The TSCTSF collects the information from the UPF/NW-TT and the SMF based on the existing procedures in Rel-17 TSC.*

**How do we map e2e DetNet requirements to per 5GS requirements?**

The DetNet configuration provides currently only e2e requirements (such as for the delay and the packet loss rate) and not per node level requirements. In other technologies, such as with fixed routers, the delay can be sufficiently controlled by existing configuration e.g., for bandwidth management, but in the case of 5GS, the required delay for the 5GS is needed as an input to the QoS setup.

As described in Solution #3, there can be two ways to perform this mapping. In simpler network deployments, the TSCTSF can be pre-configured to map the e2e requirements to per 5GS node requirements using a simple translation that is determined based on the knowledge of the given deployment. The requirements determined this way are sufficiently strict to guarantee the fulfillment of e2e requirements. In more complex network deployments, the 5GS can extend the IETF defined YANG model with a per 5GS specific delay requirement in addition to the e2e maximum delay, and the DetNet controller can make use of this additionally provided optional parameter. This applies to scenarios where both the 5GS and the DetNet controller support such an extension. In practice, YANG models are often extended according to the needs of the deployments; in our case, we can make use of the extensibility of the YANG framework by defining optional parameters that can extend the existing e2e requirements based on the needs of the 5GS. Note that if later on, IETF also defines a similar parameter extension, that can also be easily adopted; however there is currently no such work ongoing in the IETF due to the fact that typically fixed routers do not have an independent delay parameter to configure. Therefore, we propose to define such a 5GS specific parameter extension in 3GPP which can be specified without affecting the IETF YANG specification.

*Conclusion 4: The TSCTSF may use the e2e traffic requirements in the YANG configuration, and based on a pre-configured mapping, derive sufficiently strict 5GS requirements from them. Alternatively, the 5GS may make use of optional YANG extensions that allow the DetNet controller to explicitly provide the 5GS traffic requirements.*

**How is routing information handled?**

In Solution #8, the uplink routing information in the UPF/NW-TT is exposed to the DetNet controller. But this may be difficult in practice, since the routing functionality on N6 is up to implementation outside of 3GPP scope, hence defining 3GPP signalling for this purpose may be unnecessarily complex to realize and not in line with the 3GPP concept that keeps N6 routing outside the 3GPP scope.

Note also that DetNet as a technology does not require the collection of routing information from the routers; it is sufficient for the DetNet controller to collect topology information. Best effort traffic can use the existing routing mechanisms; while for DetNet flows in general, the controller may provide explicit routes. In the case of 5GS, however, it is outside the study scope to influence the routing in the 5GS. That is not necessary either, since in the 5GS deployments, we have IP endhosts in the terminal devices associated with the PDU Sessions, and the routing to the PDU Sessions is defined by the assigned IP addresses corresponding to the PDU Sessions. For the routing functionality on N6, that is proposed to be handled outside the scope of 3GPP. (In more complex deployments where there are multiple N6 interfaces and the controller needs to influence the uplink interface, the DetNet controller may explicitly interface and control the N6 router. In simpler deployments, such control may not be needed if there is only a single route possible through the 5GS for DetNet flows.)

*Conclusion 5:* *It can be possible for the 5GS to verify in the TSCTSF whether the explicit routing information provided by the DetNet controller is in line with the 5GS routing. Apart from the verification, the 5GS routing is not modified by the DetNet controller in line with the agreed scope of the work. There is no need to standardize the exposure of N6 routing information.*

**Architecture**

The following figure illustrates the DetNet architecture in line with the conclusions above.



**Which information is exposed from 5GS to the DetNet controller?**

The 5GS is exposed by the TSCTSF to the DetNet controller as a router on a per UPF granularity. Based on the discussions in Solution #1 and Solution #8, the following information is proposed to be exposed from TSCTSF to DetNet controller. The node may be identified by a Node ID. The interfaces correspond to the PDU Sessions and to the network side interfaces. Each interface is identified by an interface identifier.

* The following information may be reported from TSCTSF to DetNet controller for each interface. Type of interface
* IP address,
* subnet (prefix length)
* Neighbour address (in case of network side interfaces)
* MAC address (in case of network side interfaces)
* MTU size

The TSCTSF collects the information from the UPF/NW-TT and the SMF.

**How does the TSCTSF map the DetNet configuration to 5GS parameters?**

Based on solutions #3, #4, #6, #7, the following mapping of the parameters are proposed in the TSCTSF.

* Max-latency to Required delay
* Min-bandwidth to GFBR
* Max-loss to Required PER (new in Rel-18)
* Max-consecutive-loss-tolerance to Survival time – when such mapping is possible, such as when there is only a single packet per interval.
* Interval to Periodicity (in TSC info)
* max-pkts-per-interval \* max-payload-size to Max burst size
* max-pkts-per-interval \* max-payload-size / Interval to MFBR
* DetNet flow specification to 3GPP flow description (also including the DSCP value and optionally IPv6 flow label and IPsec SPI)

The TSCTSF uses the identity of the incoming and outgoing interfaces to determine the affected PDU Session(s) and whether the flow is uplink or downlink. The TSCTSF also determines if the flow is UE to UE in which case two PDU Sessions will be affected for the flow; in that case the TSCTSF breaks up the requirements to individual requirements for the PDU Sessions. The TSCTSF provides the parameters to the PCF.

# Proposal

We propose to update Solution 3 in 23.700-46 and add conclusions as follows.

\*\*\*\*\* START CHANGE \*\*\*\*\*\*

## 6.3 Solution #3 for Key Issue #2: Mapping from DetNet YANG model to 3GPP configuration

### 6.3.1 Introduction

The assumed architecture is shown in the figure below. On the device side, we typically have an end host as a DetNet system that makes use of the DetNet functionality. Note that the end host does not have to be DetNet aware.



Figure 6.3.1-1: DetNet logical reference architecture distribution in 5GC

The main principles of the solution are as follows.

- In the DetNet YANG model (draft-ietf-detnet-yang [5]), the forwarding sub-layer configuration and the traffic profile are for the mapping.

- The forwarding sub-layer configuration identifies the flow and the incoming, outgoing interfaces. Based on this information, the PDU Session and the flow direction (uplink, downlink or whether it is UE to UE) can be determined.

- The DetNet traffic requirements in the traffic profile include the max-latency, min-bandwidth and the max-loss, which can be converted to the 3GPP delay, GFBR and PER requirements.

- The YANG model as currently defined in IETF only includes the end to end traffic requirements. There are two options: the TSCTSF may either derive the per 5GS requirements from the end to end requirements, or the DetNet YANG model is extended for the 5GS to include also the requirements specific to the 5GS.

- The DetNet traffic specification is used to determine the periodicity and the bandwidth requirement of the flow.

### 6.3.2 Functional Description

**Parameters to consider from the DetNet controller**

The YANG model in draft-ietf-detnet-yang [5] describes the parameters that are used by the DetNet nodes to set up the configuration for DetNet. As the 5GS realizes the forwarding sub-layer, it is the forwarding sub-layer configuration that needs to be considered in the YANG model. In addition, the YANG configuration can provide the Traffic Profile that includes the traffic requirements and the traffic specification that could be used by the 5GS system.

The DetNet YANG model contains the following parameters in the traffic requirements referenced in the forwarding sub-layer which can be mapped to 3GPP parameters.

- Max-latency, which relates to the required delay in the 5GS.

- Min-bandwidth, which relates to the guaranteed bitrate that is needed for the flow (GFBR).

- Max-loss, which relates to the PER that is being proposed to be added as a new parameter in the release 18 in the 5TRS\_URLLC study that can be provided to the 5GS.

The DetNet YANG model also contains other parameters in the traffic profile that is referenced in the forwarding sub-layer which do not easily map to 3GPP parameters: max-latency-variation, max-consecutive-loss-tolerance, max-mis-ordering. There is no straightforward 3GPP mapping for these parameters as their definition differs from the current 3GPP parameters. Hence it is proposed not to standardize any mapping for these parameters in the current release.

The traffic specification referenced in the forwarding sub-layer includes the following parameters that can be mapped.

- Interval: this corresponds to the periodicity in the 3GPP system.

- max-pkts-per-interval, max-payload-size: can be used to determine the maximum burst size; together with the interval parameter, the required bandwidth can be calculated, which corresponds to the MFBR.

The traffic specification can also contain min-pkts-per-interval, min-payload-size, which do not map to any 3GPP parameters hence these are not proposed to be supported in the standardized mapping.

The TSCTSF can use the Interval to generate the periodicity value in the TSCAI.

Regarding the traffic requirements, it must be noted that the current DetNet YANG model includes only the end to end traffic requirements (e.g. in terms of maximal latency), and not the per node requirements that need to be realized by a given node. Even though it is the per node requirements that matter for the configuration of a given node, that information is currently not included in the IETF model as of today.

Based on the current IETF YANG model as currently defined, two main options can be used by the 5GS acting as a DetNet node.

- The TSCTSF derives the per node traffic requirements from the end to end traffic requirements using a pre-configured mapping in the TSCTSF, based on the knowledge of the given deployment. E.g. take a given fraction of the end to end requirements and/or subtract a constant that corresponds to the rest of the network. This mapping can be configured by the operator based on the knowledge of the given deployment’s properties, in such a way that the derived delay ensures that the e2e delay does not exceed the traffic requirements. This approach may be especially suitable for smaller DetNet deployments.

- Extend the IETF YANG model with additional parameters that apply to the 5GS system on a per node basis. The YANG modelling language allows for extensibility. That can be achieved by a 3GPP defined YANG model that imports the IETF defined DetNet YANG model and adds the needed per node parameters. In that way, the model used by 5GS remains compatible with IETF DetNet, but allows for the DetNet controller to provide the traffic requirements on a per node basis when the DetNet controller is prepared for this and when it is aware that the DetNet node is a 5GS. (That knowledge can be available based on the exposure solution in Key Issue #1.) This type of extension of YANG models is a commonly used to tailor the configuration according to the needs of a given deployment. An example for the YANG extension was provided in S2-2204764. The extension can be described in a 3GPP specification, with the possibility to further tailor the YANG model according to the operator needs of the given deployments. In this way, the IETF defined DetNet YANG model does not need to be modified (even though a future enhancement of the IETF DetNet model may consider the 3GPP defined extension). This approach may be especially suitable for bigger DetNet deployments. This alternative assumes that 3GPP defines a new YANG module for detnet, e.g. module "3gpp-detnet" that imports the module "ietf-detnet". This alternative requires that the 3GPP YANG moduleis supported by both the 5GS and the DetNet controller; otherwise we can apply the first alternative. Note that if later on IETF decides to extend the IETF DetNet YANG model with per node traffic requirement parameters, such an extension can be adopted in the 5GS; as there is currently no such work ongoing in the IETF, 3GPP can define such an extension on its own.

**Identification of the PDU Sessions**

The TSCTSF receives the DetNet YANG forwarding configuration, which refers to the incoming and outgoing interfaces in 5GS. These are based on the interface identification that is provided in the reporting from the 5GS to the DetNet controller as part of Key Issue #1 solution. The interface is identified by its name, which is derived from the if-Index, which in turn is based on the port number that is set by the UPF. The TSCTSF stores the mapping between the port number (if-Index and the corresponding interface name) and the PDU Session, hence the PDU Session can be identified. The incoming and outgoing interfaces also identify whether the flow is uplink or downlink, hence flow direction is known, and also whether it is a UE to UE flow.

The TSCTSF may also perform a verification whether the 3GPP system routes the given flow as defined in the DetNet forwarding sub-layer. Note that it is out of scope of the current study to update the 3GPP system's routing based on the DetNet configuration, but it can be possible to verify in the TSCTSF whether the incoming and outgoing interfaces in the DetNet configuration correspond to a valid routing in the 3GPP system. As an example, the TSCTSF may verify whether the destination IP address in a downlink flow towards a given interface corresponding to a PDU Session is the same IP address that is assigned for the same PDU Session. As another example, the TSCTSF may be preconfigured with the knowledge whether or not UE to UE routing is enabled or not. The TSCTSF may also verify other parameters of the configuration, and indicate that the configuration for the flow is not accepted if the configuration is outside of the supported range, based on TSCTSF preconfiguration. As a result of this optional verification, the TSCTSF may decide to accept or reject a given DetNet configuration.

In the case of a UE to UE flow, if the system allows for such traffic, the TSCTSF generates separate requests on PDU Session basis towards the PCF(s) for the uplink and the downlink legs of the flow.

**3GPP configuration for DetNet**

The PCF receives the relevant QoS requirements from the TSCTSF as well as the flow description as determined by the TSCTSF based on the DetNet configuration. The stage 3 definition of the flow description is extended according to the needs of DetNet, also including the DSCP value and optionally IPv6 flow label and IPsec SPI. The PCF determines the 3GPP QoS parameters based on the QoS requirements provided by the TSCTSF. The PCF may also consider the DSCP value in the flow description. The PCF may establish new QoS flows or modify existing QoS flows as needed.

**Deployment option: configuration of the implementation specific routing functionality on N6**

Below we clarify a possible deployment option that does not require additional 3GPP specification.

The UPF node may have routing functionality on the N6 interface side which is implementation specific. The 3GPP specifications are not responsible for setting the routing on the N6 interface side. In deployments where the implementation specific routing functionality on the N6 side also needs to be configured for DetNet, direct configuration can be used between the CPF and the routing functionality co-located with the UPF. This case can be modelled with a single interface between the UPF and the router; when the UPF and the router are co-located in the same physical node, then the interface between them can be modelled as a single virtual interface. This optional deployment is shown in the figure below. There is no need to use this option in deployments where there is no need for routing configuration by the CPF on the N6 side.



Figure 6.3.2-1: Optional deployment scenario with CPF control of N6 routing

**Other considerations**

The solution does not require an NEF between the DetNet controller and the TSCTSF, since the DetNet controller is assumed to be trusted by the operator and can influence the QoS of the traffic flows.

### 6.3.3 Procedures

The figure illustrates the procedure for the mapping of the DetNet configuration.



Figure 6.3.3-1: Signalling for setting up YANG configuration for DetNet

1. The DetNet controller provides YANG configuration to the TSCTSF. s The TSCTSF maps the configuration as described above and calculates the delay and PER requirements and the TSC Assistance Container for each flow description.

2. The TSCTSF provides the mapped parameters and the flow description to the PCF(s) on PDU Session basis.

3. The PCF(s) determines, based on the parameters received from the TSCTSF, whether the existing QoS flows need to be modified or a new QoS flow needs to be created. Additionally, the TSC Assistance Container is provided to the SMF.

4. The PCF responds to the TSCTSF, which includes information about the success of the configuration.

5. The TSCTSF provides a response to the CPF regarding the success of the configuration setup. Optionally, it can be possible to provide 3GPP specific status codes to provide additional information if the requested configuration could not be set up.

If the status of the flow changes later on for any reason, the TSCTSF notifies the CPF. Upon release of a PDU Session that is part of the existing DetNet configuration, the PCF notifies the TSCTSF for the PDU Session release, and TSCTSF notifies the CPF on status of the flow.

### 6.3.4 Impacts on existing entities and interfaces

TSCTSF: Maintains mapping between the port number in a UPF and the PDU Session and the associated interface in the DetNet configuration. Mapping of DetNet parameters and providing information to the DetNet controller whether the configuration is accepted.

PCF:

- Stage 3 definition of flow description parameter is extended.

\*\*\*\*\* NEXT CHANGE \*\*\*\*\*\*

# 7 Conclusions

## 7.1 General

The following bullet points summarize the principles for the way forward:

* YANG models over Netconf or Restconf are used between the TSCTSF and the DetNet controller.
* 3GPP does not standardize any signalling mechanism to include the NEF into the signalling path between the TSCTSF and the DetNet controller. If NEF functionality is desired, the relevant functions such as the authentication, authorization and potential throttling of signalling can be achieved by including such functionality in the TSCTSF depending on the needs of the given deployment.
* The TSCTSF terminates the interface towards the DetNet controller. The TSCTSF collects and provides exposure information to the DetNet controller. The TSCTSF collects the information from the UPF/NW-TT and the SMF based on the existing procedures in Rel-17 TSC.
* The TSCTSF may use the e2e traffic requirements in the YANG configuration, and based on a pre-configured mapping, derive sufficiently strict 5GS requirements from them. Alternatively, 3GPP may define a new YANG module (e.g. 3gpp-yang) that extends the IETF DetNet YANG modulewhich allows the DetNet controller to explicitly provide the 5GS traffic requirements.
* It can be possible for the 5GS to verify in the TSCTSF whether the explicit routing information provided by the DetNet controller is in line with the 5GS routing. Apart from the verification, the 5GS routing is not modified by the DetNet controller in line with the agreed scope of the work. There is no need to standardize the exposure of N6 routing information.

The following figure illustrates the DetNet architecture.



## 7.2 Key Issue #1: 5GS DetNet node reporting

The 5GS is exposed by the TSCTSF to the DetNet controller as a router on a per UPF granularity. The node may be identified by a Node ID. The interfaces correspond to the PDU Sessions and to the network side interfaces. Each interface is identified by an interface identifier.

The following information may be reported from TSCTSF to DetNet controller for each interface.

* Type of interface
* IP address,
* subnet (prefix length)
* Neighbour address (in case of network side interfaces,)
* MAC address (in case of network side interfaces)
* MTU size

The TSCTSF collects the information from the UPF/NW-TT and the SMF re-using the existing procedures in Rel-17 TSC, with the addition of new parameters as needed.

## 7.3 Key Issue #2: Provisioning DetNet configuration from the DetNet controller to 5GS

The parameters are mapped in the TSCTSF as follows.

* Max-latency to Required delay
* Min-bandwidth to GFBR
* Max-loss to Required PER (new in Rel-18)
* Max-consecutive-loss-tolerance to Survival time – when such mapping is possible, such as when there is only a single packet per interval.
* Interval to Periodicity (in TSC info)
* max-pkts-per-interval \* max-payload-size to Max burst size
* max-pkts-per-interval \* max-payload-size / Interval to MFBR
* DetNet flow specification to 3GPP flow description (also including the DSCP value and optionally IPv6 flow label and IPsec SPI)

The TSCTSF uses the identity of the incoming and outgoing interfaces to determine the affected PDU Session(s) and whether the flow is uplink or downlink. The TSCTSF also determines if the flow is UE to UE in which case two PDU Sessions will be affected for the flow; in that case the TSCTSF breaks up the requirements to individual requirements for the PDU Sessions. The TSCTSF provides the parameters to the PCF re-using the existing procedures in Rel-17 TSC, with the addition of new parameters as needed.

The TSCTSF provides a response to the DetNet controller regarding the success of the configuration setup. Optionally, if 3GPP may defines a new YANG module that extends the IETF DetNet YANG module, the 5GS may provide 3GPP specific status codes foradditional information if the requested configuration could not be set up.

If the status of the flow changes later on for any reason, the TSCTSF notifies the DetNet controller. Upon release of a PDU Session that is part of the existing DetNet configuration, the PCF notifies the TSCTSF for the PDU Session release, and TSCTSF notifies the DetNet controller on status of the flow.

\*\*\*\*\* END CHANGE \*\*\*\*\*\*