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ENHANCING SLICE AWARENESS OF 5G RADIO ACCESS NETWORK USING SELF-ORGANIZING NETWORK

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ABSTRACT

Techniques are described herein for enhancing the slice awareness of a Radio Access Network (RAN) using a Self-Organizing Network (SON). This may solve the problem of slice allocation to a gNodeB (gNB), monitor the slice resources of the gNB and the handover of devices which are registered to a slice, and reduce handover time. In addition, the SON may push slicing policies for the gNB such as hardware based slicing, scheduler based slicing, geography based slicing, etc.

DETAILED DESCRIPTION

Long-Term Evolution (LTE) Advanced introduced the concept of network slicing, in which a network can be sliced vertically or horizontally for a given service level agreement. 5G continues to support this concept, and the network slices remain isolated such that one network slice does not affect another. A device can send the slicing assistance information in a Radio Resource Control (RRC) message. The Radio Access Network (RAN) node selects the Access and Mobility Management Function (AMF) based on the required Single-Network Slice Assistance Information (S-NSSAI) for the device and the availability of the slice.

A 5G device that has subscribed for a network slice is serviced by the RAN nodes. The gNB is aware of the supported NSSAI by each AMF to prevent querying. Some of the slices may be geography dependent, and there may be seamless slice-aware mobility to reduce handover failures. The gNB may be aware of the load of neighboring gNBs that support the NSSAI to reduce handover rejects. Slice-aware idle mode mobility (cell reselection) may be supported by the gNBs.

As illustrated in Figure 1 below, NSSAI support of the AMF and RAN nodes (gNB and cells) and additionally the Session Management Function (SMF) / User Plane Function (UPF) are managed by a Self-Organizing Network (SON) using proprietary interface(s) to

those nodes. The SON assisted NSSAI support of the AMF selection and slice aware handover / load balancing across RAN nodes (gNB and cells) may provide improved service and user experience in 5G. The SON may interface with the RAN and AMF using proprietary/standard interface(s). The SON subscribes to the AMF (or the Network Slice Selection Function (NSSF)) to learn the supported NSSAI list. It publishes, to the RAN, the NSSAI-to-AMF mapping based on configuration, geography, instance, etc.

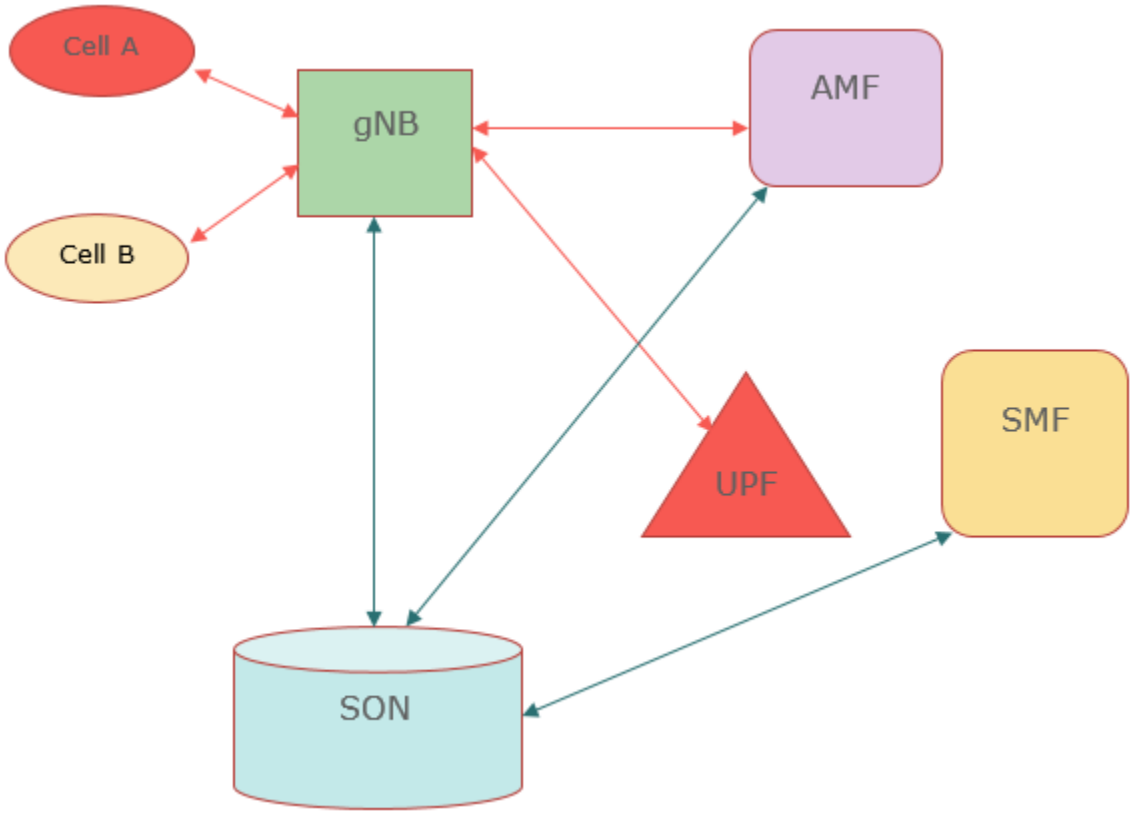

Figure 1

As illustrated in Figure 2 below, the 5G cell geographical location and associated gNBs are available with SON through the Operation Support System (OSS). The SON maintains the geographical NSSAI list and shares it with the RAN. The gNB information and the AMF connection information are available with the SON. The 5G cell and gNB may whitelist or blacklist NSSAI data with the SON. The supported slice information may be available to the SON from the OSS. The cell neighbor list creation may be slice aware, and the load information of cells of the gNB and NSSAI related resources may be available with the SON. The SON may thus perform slice aware load balancing.

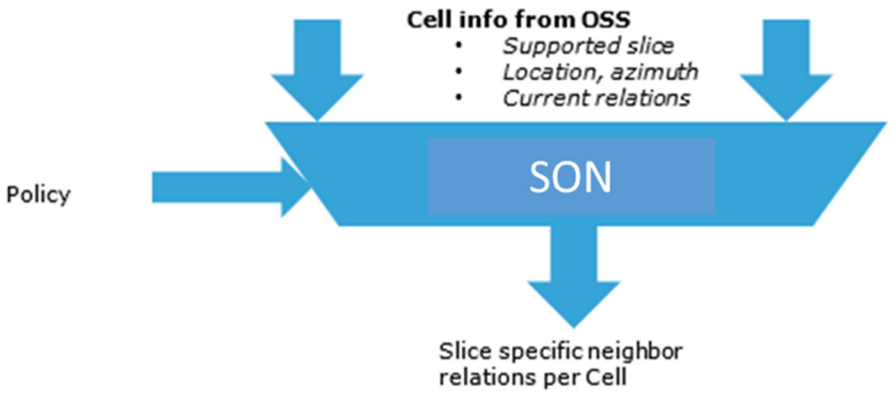

Figure 2

The AMF subscribes to the SON, providing the information from the NSSAI list it supports and the geography it can serve. The SON converts the Single NSSAI (S-NSSAI) to an AMF table. The SON may also convert the geography to the AMF table. The SON may share the S-NSSAI to AMF table as appropriate for the gNB geography.

Figure 3 below illustrates conversion from the master S-NSSAI to the AMF table.

Master S-NSSAI -> AMF table

S-NSSAI	AMF
abc.x1	AMF-x1, AMF-c1
abc.y1	AMF-y1, AMF-c2
cda.x1	AMF-x1
kjh.x1	AMF-b1
kjh.z1	AMF-c1

Figure 3

The gNB subscribes to the SON, providing information of the cells that serve under it and the geographical location of the cells. The SON retrieves, from the gNB/OSS, information of the cells (including the supported slice) that serve under it and the geographic location of cells. In addition, an operator may configure which NSSAI the gNB

intends to support. The operator may also restrict cells under a gNB to support only a some NSSAIs. The operator may further configure the location information of the AMF.

Based on this information, the SON may allocate the AMF closer to the gNB along with the supported NSSAI list. The NSSAI list provided by the set of AMFs to which the gNB connects may be treated as the superset of the NSSAI list supported by the gNB. The gNB may support a subset of the NSSAI list based on the whitelisting/blacklisting of the NSSAI. For each NSSAI, the SON may retrieve from each gNB/OSS periodic load information at both gNB and cell level granularity.

Figure 4 below illustrates conversion from the gNB S-NSSAI to the AMF table.

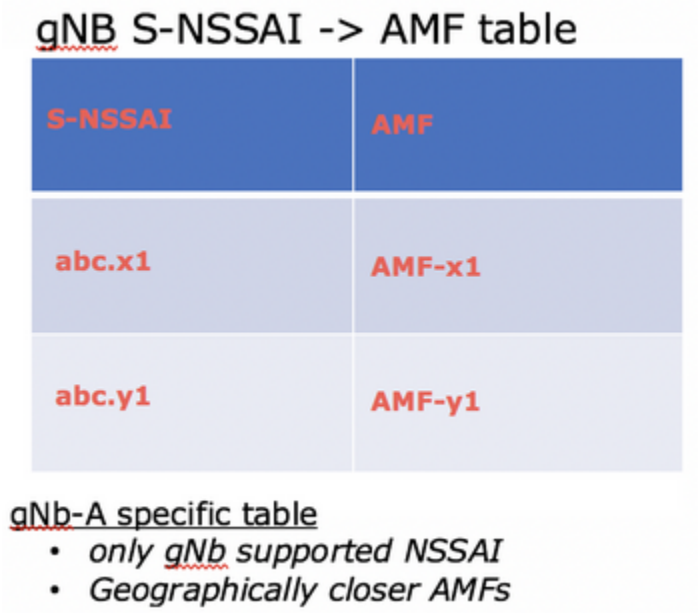

Figure 4

The SON may periodically determine the neighbor cells based on slice and create neighbor relations in gNb cells. NSSAI list creation occurs for each gNB/cell. This list is published to a neighboring gNB. The individual NSSAI load is provided for each node.

Figure 5 below illustrates example neighbor cell data stored in the SON.

Neighbor Cell information

Neighbor cell	gNB of cell	Slice name	Slice load
Cell1	gNB_1	M-IOT	80%
Cell1	gNB_1	Enterprise	40%
Cell2	gNB_1	Connected cars	50%
Cell2	gNB_2	Enterprise	20%

Neighbor gNB information

Neighbor gNB	Slice name	Slice load
gNB_1	M-IOT	80%
gNB_1	Enterprise	40%
gNB_2	Connected cars	50%
gNB_3	Enterprise	20%

Figure 5

Using this information, the gNB may redirect the User Equipment (UE) service along with assistance information to the correct AMF or reject the UE service if the slice is not supported by the gNB or the cell through which the request arrived. The gNB may also/alternatively redirect the UE through a RRC reject to an intra-cell destination that supports the slice or to an inter-cell destination at the neighboring gNB that supports the slice.

The gNB may build a Neighbor Relation List (NRT) for each NSSAI. This list may be used while configuring a measurement object for the UE that supports the respective NSSAI. The load information per NSSAI may be used to reject the UE admission request for a gNB or a cell under that gNB. Based on the NSSAI support of neighbors, the gNB may establish a connection to the neighboring gNBs that support some of the common NSSAIs.

Figure 6 below illustrates example interactions between the SON and entities in a network with four slices.

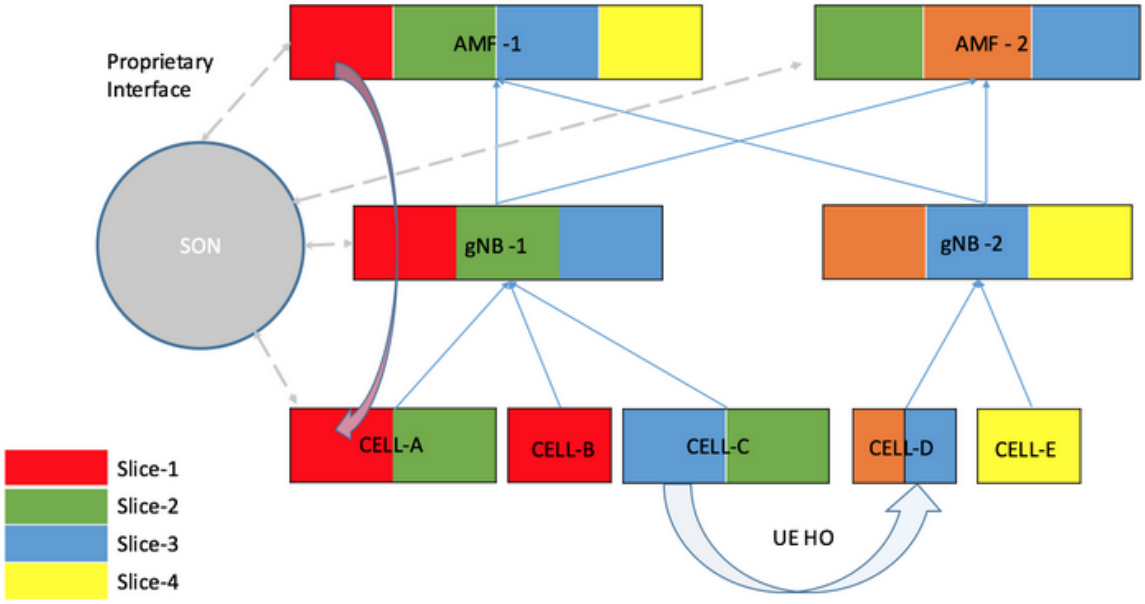

Figure 6

The SON may enable NSSAI load management. The SON may configure a threshold based on slice policy. RAN slicing may be achieved through any suitable method (e.g., Physical Resource Block (PRB) resource reservation per slice, hardware resource allocation per slice, cell resource allocation per slice, scheduler based slice management, etc.).

Figure 7 below illustrates SON configuration of a slice on the gNB.

Slice Name	Slice Resource policy	Resource threshold
M-IOT	Scheduler based	90%
Enterprise	Cell	90%
Latency sensitive	PRB	80%

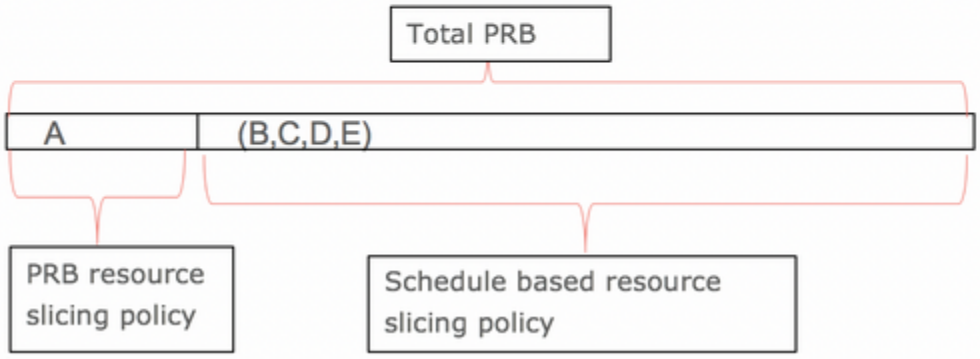

Figure 7

The gNB may perform admission control on the slice or handover the devices from the slice when the resource utilization of the slice exceeds the resource utilization threshold configured by the SON. The gNB may report load information per slice for the entire gNB and the cells under the gNB. The SON may then publish this information to neighboring gNBs. The neighboring gNBs may use this information to build the NRT.

The AMF may register the supported NSSAI and its geography information with the SON using a proprietary interface (in absence of standard interface). The gNB NSSAI list may be a superset of the NSSAI list configured for cells under it and the operator configured NSSAI list for the gNB. The gNB may query the SON server with its NSSAI list and the SON server may allocate the AMF or list of AMFs based on the NSSAI list and the geographic location of the gNB.

The SON may collect load information for each network slice at the gNB level (aggregated load) as well as for cells under the gNB. The SON server with its global view may configure the neighbor list / NRT per network slice for each cell. The gNB may use the slice configuration, load information per slice, and neighbor information per slice to perform admission control, and may perform load balancing using a redirect and handover per slice. The gNB/cell may pass the slice based load information to the SON and use the slice information obtained from the SON to perform admission control and handover.

In summary, techniques are described herein for enhancing the slice awareness of a RAN using a SON. This may solve the problem of slice allocation to a gNB, monitor the slice resources of the gNB and the handover of devices which are registered to a slice, and reduce handover time. In addition, the SON may push slicing policies for the gNB such as hardware based slicing, scheduler based slicing, geography based slicing, etc.