White Paper on TSDSI's 5G Radio Interface Technology

5Gi is one of the Radio Interface Technologies (RITs) proposed by TSDSI (Telecom Standards Development Society India) and approved by ITU as a candidate technology for 5G.

ITU approved 3 Radio Interface Technologies (RITs) in Nov 2020 as the candidate RITs that meet all the requirements for 5G as outlined in IMT-2020 requirements. Following are the 3 approved RITs:

1. 3GPP RIT - defines the specification for 5G NR (New Radio) operating at FR1 and FR2 spectrum in 3GPP release 15 and beyond. This specification provides all details related to NR. This set of specification is applicable to gNB.

2. 3GPP SRIT - defines a set of specifications for LTE (E-UTRA, Evolved Universal Terrestrial Radio Access) and NR (new radio) operating at FR1 (LTE + NR) and FR2 (NR) spectrum in 3GPP release 15 and beyond. This set of specifications are applicable to both ng-eNB and gNB.

3. 5Gi – defines the specification for 5G NR to support a use case to extend the inter-site distance of the base stations that will promote rural broadband. This specification applies to gNB operating at FR1 and FR2 spectrum. While ITU has approved this specification, the configuration required to activate this interface is made optional in 3GPP. However the feature can be activated with minimal changes in the User Equipment (UE) and gNB. The feature can be activated at gNB with a software upgrade.

All the 3 RITs meet all the performance requirements in the 5 deployment scenarios outlined by ITU, i.e.

a. Indoor Hotspot – enhanced Mobile Broadband (eMBB),
b. Dense Urban – eMBB,
c. Rural – eMBB,
d. Urban Macro – Ultra Reliable Low Latency Communication (URLLC) and
e. Urban Macro – massive Machine Type Communication (mMTC)

The key focus of 5Gi is to support the Rural Communication needs in a cost-effective manner. The 5Gi considers a low mobility use case for rural communication to extend the inter-site distance to reduce the deployment cost substantially. 5Gi introduces a new waveform to boost power in the Uplink channel by 3dB. Pi by 2 BPSK waveform can achieve a coverage distance of 12 Km (under Line-of-Sight condition) with an average UE power of 23 dBm (max power of 26 dBm) and offers a 100kbps throughput at the cell edge. This throughput is good enough for making a video call from the cell boundary. Please note that the power boost can be applied to higher order modulation schemes to extend the range, if we don't violate the average power level of 23dBm for the specified device category. When 5Gi configuration is used, the UE and the gNB need to support an additional modulation scheme called Pi by 2 BPSK that enables extending the range of the base station or the inter-site distance of the base stations.

Key driver for 5Gi waveform

Primary intent behind this standard is to bridge the rural-urban digital divide in 5G deployment by supporting enhanced coverage. From Indian context this enables connectivity in villages through

towers located at gram panchayats in a cost-effective manner. Standard has received support from several countries as it can addresses the regional needs from a 5G standpoint.

5Gi if implemented has a great potential of reducing the CAPEX and OPEX for rural broadband network solving the last mile connectivity issue, thus realizing our Honorable PM's vision for Digital India.

After making the head start with contribution to standard, onus is on us to take this innovation forward to build protype to demonstrate the effectiveness of the proposed modifications to enable wider industry adoption of the standard.

Key features of 5Gi and challenging in adoption

All of us in the industry agree that cellular network range are limited by the power output of cell phones or UEs. Any effort towards improving the coverage must focus on UE side transmitter and Base station side receiver. Key essence of the 5Gi contribution can be listed as below

i) Introduction of a new waveform that supports pi/2 BPSK modulation with spectrum shaping at the UE side transmitter. Corresponding receiver side algorithms at gNB side is expected to enhance the cell edge performance by 3 dB (2 times).

ii) The new waveform offers enhanced performance on the peak to average power ratio (PAPR). In addition, the waveform is very resilient to non-linearities that offer reduced EVM (error vector magnitude) even when the Power amplifier is driven to saturation.

iii) The new waveform enhances uplink throughput almost by double at cell edge.

iv) The UE transmitter is required to use DFT-s-OFDM in addition to supporting CP-OFDM

From technology perspective no doubt 5Gi is an important extension and has potential for enabling large cell deployments. For adoption of the technology, it is important that the changes are done at both infrastructure side as well as User Equipment side. Teams from 5G test bed have demonstrated the performance in simulation as well as in the laboratory tests with RF. This is an important step in proving the technology but for wider industry adoption it is essential to develop and demonstrate workingprototype5Gi based network in the field deployment scenario.

Below list of points capture the background of challenges for 5Gi adoption and details the efforts by different organizations in addressing them.

a. It is possible to make changes required on base station side to demonstrate 5Gi but there is a challenge in getting the 5Gi support from UE/device side.

b. The device side requires a few changes including a simple filter implementation. Chipset makers like Mediatech, Apple, Qualcomm are important. During the recent visit of Hon'ble

PM's to USA, press reports indicated that issue was broached with the Head of Qualcomm for support. IITM is also holding discussions with Mediatech.

c. OEMs are taking it as a matter of principle that 5Gi implementation is likely to enable IITM / IITH/ TSDSI as part of the elite club where they will need to cross license their IPRs for using 5Gi IPRs of IITM/IITH in return.

d. 3GPP, driven by OEMs appears reluctant to enable a few reserved bit fields (called non-critical extensions) for enabling interoperability and co-existence of 5G and 5Gi devices on the same network.

e. Independently IITM has come out with a list of modifications to 5G procedures to implement 5Gi with minimum changes. However, this requires demonstration on the ground. Hence, a campus trial using 5Gi UEs (User Equipment) is the need of the hour to get confidence from the operators.

f. Once 5Gi is made a mandatory standard in India, 3GPP would be compelled to embrace 5Gi as part of the standard. In recently concluded 3GPP meetings, the OEMs appeared reluctant to include it as part of the program plan for release 18.

DoT could offer some incentive for OEMs for Infrastructure and UE who are willing to make 5Gi changes. We propose prototyping the 5Gi leveraging capabilities of Indian telecom Industry players elaborated in further sections as an independent path.

In summary DoT India should adopt both carrot and stick policy to address the 5Gi challenge where one or both the approach may yield results.

Proposed Solution

We propose announcement of a 5Gi Prototyping program that **can have R&D fund for building 5Gi prototypes**. **Multiple consortiums shall be formed led by large government or private companies tasked with responsibility of building Base station and User Side equipment.**

Each consortium to identify partners with technology ownership and start integrating the solution on both UE and BTS. The UE side consortium preferably be led by an integrator with past experience in building chips. Funding should be released respective consortium based on the Technology Readiness Level (TRL) achieved. To ensure competition and better success rate at least 2 consortium each should be considered for UE and BTS.

Each consortium should conduct campus or pilot trials and demonstrate interworking with standard 5G equipment and 5Gi mode interworking among other consortium prototypes.

Successful Base station side consortiums should be allowed to participate in 5G network roll out as a reward.

Successful UE side consortium should be ensured with further funding to build the chipset.

Team worked on 5Gi standard to mentor and support all the consortiums with respect to 5Gi specific algorithms and modifications.

Spectrum Allocation strategy to promote 5Gi adoption

DoT should consider reserving NR band 71 in the range of 663-698 MHz for rural broadband network that implements 5Gi technology. This is a premium frequency band that can give large coverage. With 5Gi, the range can be extended further. This can be a strategy for promoting 5Gi independently.

To conclude, there is a **golden opportunity for DoT to bind the scattered Indian 5G telecom companies to achieve a common objective of prototyping 5Gi technology and we strongly believe strategic planning around 5Gi technology can pave way for Indian Industry to lead global telecom market.**