Cirrus360 Corp.'s response to 5G Challenge Notice of Inquiry

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Summary:

- 5G is all about flexibility and evolution, to service a rich and evolving set of applications, in deployments by the government and DoD as well as the commercial sector. The 5G system is not a single static stack that can be built by a one-time integration of a set of components. For a particular deployment, only a subset of the complete 3GPP specification is used. Moreover, government and defense use may require extensions to the base 5G standard, especially with respect to security and QoS guarantees. Hence, the standard and its use will continue to evolve and the deployments and capabilities will also continue to do so. So the 5G Challenge needs to address the flexibility and evolution path support of 5G.

  The 5G Challenge should be about proving the ability to disaggregate the 5G system and compose with agility, rather than about specific feature goals*, or about creating a single reference stack.*

- The Radio Access Network Layer 1 (RAN L1 or PHY) and Layer 2 (L2) represent the lion's share of the R&D time, as well as CAPEX and OPEX in today's cellular systems. This is because of a set of unique constraints in the RAN related to firm real time, security, power, and robustness in the field. If L1 and L2 are not disaggregated and opened, both from a hardware to software, and software to software perspectives, progress in opening up the higher layers will do little to move the market beyond its dependence on a few large players.

  The 5G Challenge should have a deliberate focus on an open, modifiable, and productizable Layer 1.

- In the context of this document, we refer to "open 5G" to imply not only open interfaces, but a dis-aggregation and composition framework where intellectual property (IP), both hardware (HW) and software (SW), from multiple vendors, including small companies providing a piece of the solution, can be securely and robustly integrated to compose an end to end 5G system. With this goal, the 5G Challenge can enable a new era of US innovation in wireless infrastructure for commercial and government/defense markets.

  The 5G Challenge needs to address integration of hardware and software stack components from both large players as well as small innovators who may have deep expertise in a specific component of the 5G stack.

- *Our company, Cirrus360 Corp., is developing an intent-driven, domain-specific automation system for RAN (product name: GABRIEL) to address the problem of long development, modification, integration, and verification cycles for "open 5G" stacks.*

  This enables system level composition and configuration of trusted, disaggregated RAN software onto limited hardware, without deep knowledge of component functionality or real time systems expertise. GABRIEL enables addition of new QoS and security guarantees to 5G systems, *extending* emerging open RAN and 5G standards from consumer and customized enterprise use, to making 5G work for security sensitive DoD applications and use cases.

I. Challenge Structure & Goals

A. How could a Challenge be structured such that it would take advantage of DOD's role as an early U.S. Government adopter of 5G technology to mature the open 5G stack ecosystem faster, encourage more participation in open 5G stack development including encouraging new participants, and identify any roadblocks to broader participation?

To encourage more participation and mature the ecosystem for 5G, the Challenge must allow smaller players to demonstrate differentiating capabilities without having to partner with larger incumbents just to get to the scale needed to enter the Challenge. If large projects are a defacto requirement then the 5G Challenge will see "the usual suspects" and little will be done to broaden the potential ecosystem for 5G in the US. The Challenge should be structured to encourage small businesses and innovators in specific areas, such as massive-MIMO, intelligent reflextive surfaces or network slicing, to integrate their IP with bigger systems programmatically (without point to point specific collaborations). To achieve this, the Challenge could provide a default solution scenario and set improvement goals for this scenario.

For instance, a certain open source project (e.g. [4], [5], [6]) and/or reference design (e.g. [2], [7]) can be chosen as a baseline, and participants could be challenged to improve it in specific ways, such as security, algorithmic performance, integration with machine learning based algorithms in higher layers for system performance, prove portability of a common software stack across multiple hardware platforms, or demonstrate improved Continuous Integration and Development (CI/CD) [3] with frequent code commits.

B. How could a Challenge be structured to focus on the greatest impediments to the maturation of end-to-end open 5G stack development?

One of the greatest impediments to maturation is the lack of an ecosystem *integration* framework where many small and large players can contribute profitably in an open environment for 5G. An ecosystem as well as integration framework where innovation can occur at small start ups and medium sized corporations should be encouraged if the US is to take a leadership role in 5G. The Telecom Infra Project (TIP) [1] and O-RAN Alliance [4] ecosystems have made good progress in this regard – with the TIP community using O-RAN Alliance standards to productize and commercialize open architecture solutions driven by operator needs.

The DoD can play an important role in encouraging US innovation in this area.

Historically, it has been difficult for small innovative companies to participate in the telecom infrastructure business, because of the dynamics of the eco-system and the unique characteristics of the deployed system regarding power, cost, and robustness constraints. This has led to the dominance of a few large players who have the R&D capacity and expertise in all parts of the end to end system, i.e. RAN to core to services [8]. This is especially true in the RAN due to the lack of dis-aggregation and the dependence on a small set of large players to provide robustness and integrity guarantees end to end. The only way for smaller companies with specific expertise in a particular component of the stack to take their innovation to deployment, has been to collaborate closely with one of the larger infrastructure vendors. This has traditionally been a discouraging business model for small, innovative US players.

The open RAN movement seeks to disrupt the above business and technology model, but needs the benefit of automation frameworks that enable systematic integration of IP (hardware and software) from multiple small and large companies, without negatively impacting the integrity of the end to end system. This is most critical in L1 and L2 because these account for the majority of the CAPEX and OPEX in the network. Vendor lock-in in one part of the stack will lead to vendor lock-in in the ecosystem as a whole.

The 5G Challenge should encourage the kind of open 5G interfaces that allow the integrated system to remain dynamic through its lifecycle, allowing multiple vendors to contribute hardware or software intellectual property (IP) that can be integrated post-deployment.

C. What should be the goals of a Challenge focusing on maturation of the open 5G stack ecosystem? How could such a Challenge be structured to allow for the greatest levels of innovation? What metrics should be used in the assessment of proposals to ensure the best proposals are selected?

Maturation of an open 5G ecosystem requires that software innovators can focus on one aspect of the stack and successfully introduce a product without dependence on support from larger players in the ecosystem, (who may want to protect their position in one layer by leveraging their position in another). Also, hardware innovation must allow for the software stack to be ported to disparate platforms. This is especially true in the lower layers of the stack (L1, L2) where real time requirements and power constraints lead to heterogeneous, accelerated hardware solutions. Therefore the 5G Challenge should focus on automation (tooling) and architecture structures that allow the open disaggregation of software components from each other and also from hardware, even when there is heterogeneity and power constraints in the hardware architecture.

Metrics to evaluate progress in the Challenge could include time taken to adapt to a new set of requirements, number of significant code commits, cross layer test cases – as measures of agility and flexibility of the integration.

D. How will the open 5G stack market benefit from such a Challenge? How could a Challenge be structured to provide dual benefit to both the Government and the open 5G stack market?

The commercial market will benefit from interoperability and disaggregation, from the perspective of controlling CAPEX and OPEX (e.g. improving system level power efficiency). Otherwise it will become dominated by a few 5G infrastructure equipment players as is the case today for 4G. Interoperability and disaggregation allow the Government to source solutions with unique requirements (for instance in security) that are constructed from trusted software and hardware components. Additionally, the US can leverage its strengths in the CBRS band, and the diversity of applications it promises, into a leadership position in 5G, if the solution ecosystem allows for the variety of infrastructure deployments that are made possible by disaggregation.

The 5G Challenge can be structured to focus on one or more use cases that meet the needs of both government and commercial markets: e.g. addition of a new security class to a base solution; port RAN software between two hardware platforms without re-writes; integrate higher layer (e.g. RAN intelligent controller or RIC) machine learning smarts onto a flexible L1; and so on.

II. Incentives and Scope

A. What are the incentives in open 5G stack ecosystem development that would maximize cooperation and collaboration, promote interoperability amongst varied open 5G stack components developed by different participants, and mature desired featured sets faster with greater stability?

The open 5G stack ecosystem development needs to expand to allow for HW/SW and SW/SW interoperability within the lower layers of the stack. In particular the L1 and L2 layers represent the lion's share of the CAPEX and OPEX today in cellular systems and if these are not disaggregated, progress in the higher layers will do little to reduce dependence of the market by a few large players, both in hardware and system integration. This will in turn be an impediment to the development of rural connectivity where large players have little incentive to differentiate their product for a limited market, but where innovation is most keenly required.

The open RAN eco-system building and specifications efforts currently underway at the Telecom Infra Project (TIP) [1] and the O-RAN Alliance [4], are paving the way for dis-aggregation and ecosystem interoperability. This Challenge can provide an opportunity to expand on that work and add SW to SW, as well as SW to HW, disaggregation on top of the module to module disagreggation enabled by the O-RAN interface specifications.

For this 5G Challenge to encourage smaller players to come in with innovative solutions, without having to become sub-contractors to larger players, the Challenge should include some financial assistance to small players competing in the Challenge and willing to put a significant portion of their company's resources into the Challenge.

B. Could a Challenge be designed that addresses the issues raised in previous questions and also includes test and evaluation of the security of the components?

A minimal requirement would be for the Challenge to allow for software disaggregation especially in L1/L2 and to allow for these layers to be transparent to higher layer network optimization strategies. To design this Challenge we recommend the use of a canonical platform on which the ability of contestants to manage component updates, demonstrate CICD, and integrate new algorithmic components should be evaluated. Transparency to the network could include the ability to open up new data analytic access to the lower layers and show how this could be used to optimize power and performance of L1.

Such a platform can then be used to demonstrate security management in the L1, especially for a COTS hardware platform where system vulnerabilities are much better understood by malign actors and therefore security becomes more critical.

C. Could a Challenge be designed that would require participants to leverage software bill of materials design principles in the development of components for an open 5G stack?

Given the many deployment configurations and feature combination that are possible with 5G to meet a wide range of use cases and applications, release management of the integrated 5G stack is imperative. Integrating NTIA's software bill of materials concepts [9] into the *automation* framework for RAN can be part of the Challenge.

D. Many open 5G stack organizations have developed partial implementations for different aspects of an open 5G stack. What portions of the open 5G stack has your organization successfully developed with working code? What portions of the open 5G stack does your organization believe can be developed quickly (6 months or less)? What development support would best enable test and evaluation of the different elements of an open 5G stack?

Today, operators and enterprises deploying 5G RAN, do not have the solutions necessary to truly scale systems based on open RAN principles and harness all the advantages it promises (lower cost and open up new monetization opportunities).

Our company, Cirrus360 Corp., is developing an intent-driven, domain-specific automation system for RAN (product name: GABRIEL) to address the problem of long development, integration, and verification cycles for "open 5G" stacks, This enables system level composition and configuration of trusted, disaggregated RAN software onto limited hardware, without deep knowledge of component functionality or real time systems expertise.

GABRIEL enables addition of new QoS and security guarantees for customized edge computing solutions, extending emerging open RAN and 5G standards from consumer and customized enterprise use, to making 5G work for security sensitive DoD applications and use cases. Furthermore, the US government and DoD use cases

eventually needs to customize/modify the PHY of 5G to be more resilient to jamming and detection. GABRIEL enables this to be done more quickly and reliably while keeping backward and forward compatibility with the rest of the evolving 5G network.

We expect that GABRIEL will be used as a mechanism to allow multiple participants to be profitably involved in the development of different aspects of the dis-aggregated stack, which can be composed while enforcing real time and security.

We are working with the Telecom Infra Project (TIP) to bring our intent driven, domain specific RAN automation concept to the eco-system.

E. What 5G enabling features should be highlighted in the Challenge, such as software defined networking, network slicing, network function virtualization, radio access network intelligent controller, radio access network virtualization?

The 5G Challenge should be about the ability of 5G to disaggregate and compose with agility, rather than about specific feature goals.

Extending network slicing to the lower layers is critical for 5G open stack development. The RAN Intelligent Controller (RIC) from O-RAN can be used to demonstrate how higher layer near real time applications can be used to optimize network performance by manipulation of, and analytics on, the L1 and L2 layer implementations.

III. Timeframe & Infrastructure
A. What software and hardware infrastructure will be needed to successfully execute this Challenge?

- A baseline open source L1/L2 solution or reference solution will be needed. Examples: [4][5][6][7]
- A code development and CI/CD environment (optional). Example: [3]
- At least two different RAN hardware platforms will be needed. Examples: [10][11][12]
- A 5G testbed such as those developed in academia. Examples: [13][14]

The choice of above HW and SW infrastructure components may be left upto each Challenge participant, or group of participants, or may be a part of the design of the Challenge itself.

B. What is a reasonable timeframe to structure such a Challenge? Should there be different phases for such a Challenge? If so, what are appropriate timelines for each suggested phase?

Phase one could be a 6 months Challenge to show how software disaggregation from the baseline platform can be achieved and how new components can be added in a CICD manner while maintaining real time and power constraints.

Phase two could be a 6 to 12 months Challenge to demonstrate how the code developed in the first phase could be ported to additional hardware platforms. This would then be a joint Challenge for software architecture and hardware platform teams.

REFERENCES:

[1] TELECOM INFRA PROJECT (TIP): (link)

[2] TIP OPENRAN project group.: (link)

[3] TIP OPENRAN CI-CD: (link)

[4] O-RAN Software Community: (link)

[5] OpenAirInterface Software Alliance: (link)

[6] Open-source LTE software radio suite developed by Software Radio Systems (SRS): (link)

[7] Intel FlexRAN Software Wireless Access Solutions: (link)

[8] Network Architecture domains: (link). Ericsson.

[9] NTIA Software Bill of Materials (Introduction to SBOM): (link)

[10] Intel open RAN products: (link)

[11] Nvidia Aerial SDK: (link)

[12] Marvell 5G base station hardware products: (link)

[13] CCI 5G Research Testbed. Virginia Tech. (link)

[14] Platform for Open Wireless Data-driven Experimental Research: (link)