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Comments and Recommendations regarding 5G Challenge Notice of Inquiry
NTIA RIN 0660-XC049, Docket No. 210105-0001

Organization and Identity

This comment is submitted by Harald Welte, the founder and managing director of *sysmocom – s.f.m.c. GmbH*, a German company specializing exclusively on R&D of open source in mobile communications. Harald is also the founder and lead developer of the Osmocom (Open Source Mobile Communications) project, a project that is home to more than 70 individual open source software and open source hardware has spearheaded the open and collaborative development of open source in the field of cellular communications since 2008. Osmocom software – today primarily for 2G and 3G networks, and to some extent in 4G - is used in research, academia, by small/private operators and commercial telecom operators or equipment suppliers alike. Some letters of support from a selection of our users can be found at https://osmocom.org/projects/cellular-infrastructure/wiki/Letters_of_Support.
Harald is a former Linux kernel developer and has 25 years of experience working exclusively in and on open source software. He has received several awards, such as the Google + O'Reilly Open Source Award[1] amd the FSF's annual Free Software Award[2] in recognition of his work.

General Comments

Importance of the definition of “Open”

The call for comments refers at several locations to “Open 5G”, “open source software” and also “open 5G stack components”, etc. - It is very important for any related challenge to have a very clear definition and common understanding of what this actually refers to.

1 https://en.wikipedia.org/wiki/O'Reilly_Open_Source_Award#2008
2 https://www.fsf.org/news/2007_free_software_awards

It is important to realize that various different players are using the term "Open" while referring to completely different topics – often intentionally using this confusion to ride on the generally positive connotation of "open source" while at the same time actually talking about something else. This is sometimes referred-to as "open-washing" in an analogy of the term "green-washing" coined in the environment movement.

1. **Open Interfaces**
   All of modern cellular communications is based on open interfaces. The interfaces and protocols are specified by standards bodies like ETSI, 3GPP, and the interfaces even in the venerable 2G (GSM) standard are open interfaces. "Abis" between BTS and BSC, "A" between BSC and MSC, etc. - there is hardly anything conceptually new in terms of 5G. However, there is some movement outside of 3GPP to defining additional interfaces inside the base station itself (OpenRAN, O-RAN), but that is just the logical extension of the decade-old principle of specifying inter-operable, standardized interfaces between network elements in cellular networks.
2. **Open Source Software**
   Open Source Software, sometimes also called Free/Open Source Software (FOSS) is software governed by very specific license terms. There are three decades-old commonly recognized definitions by three different bodies defining the requirements to qualify as FOSS:
   1. The Open Source Definition[3] of the Open Source Institute (OSI)
   2. The Free Software Definition[4] of the Free Software Foundation (FSF)
   3. The Debian Free Software Guidelines[5] of the Debian project (DFSG)

   Those definitions have been accepted by the Open Source community for decades. Unfortunately the definition of "Open Source" is under attack by various industry players, particularly in the Telecom industry. They invent licenses that are not in compliance to either of those commonly established definitions and then call them "Open Source" or even more confusingly "Open Software". It is very important to note that only software complying to at least one of the decades-old definitions above conveys the benefits and freedoms associated with "Open Source Software", namely (at least)
   - the freedom of non-discriminatory use by anyone for any purpose
   - the availability of the software in source code format
   - the freedom to study and improve the software
   - the freedom to redistribute modified and unmodified versions
3. **Open Standards**
   This term is unfortunately not very well defined. Particularly within the Industry, the term is often used in the context of standards with essential patents under so-called "FRAND" patent licensing schemes, which are often mutually incompatible with many open source licenses, or which at least exclude any patent holder or patent licensee from actively contributing to open source software. The Open Source Initiative has published a summary of the positions of various Open Source related entities on so-called open standards[6].

3 https://opensource.org/osd
4 https://www.gnu.org/philosophy/free-sw.en.html
5 https://www.debian.org/social_contract.html#guidelines
6 https://opensource.com/resources/what-are-open-standards

Therefore, it is considered of utmost importance to clarify which exact open-ness requirements are put forward for any related challenge. The degree of open-ness could also be part of a metric in the assessment of the proposals, with work covered under true (OSI OSD compliant) open source licenses rating highest.

I. Challenge Structure & Goals

As the "Supplementary Information" points out, there are many different open 5G stack organizations with no clear division among the multiple implementations, and with no clear focus on interoperability between the projects.

It is recommended to focus on extensive functional testing of all relevant (external, interoperable) interfaces. Such testing should ideally be performed against a to-be-created open source test suite for functional testing of the relevant interfaces. If one such test suite project was started/funded and published as Free/Open Source software, all implementors of 5G network elements / functions could validate their implementation against that test suite. This would help

- the projects to realize themselves their level of compliance to the related protocol specification
- any potential users (government or public) to evaluate the maturity and completeness of a given implementation

A proposed open source 5G functional test suite would primarily, in the first step, be a functional test suite. That is: Test individual procedures as specified in the relevant protocol/interface specifications and execute both successful and unsuccessful scenarios of each relevant procedure at the related interface. In further, optional, secondary development, the tests could be extended to include performance / scalability testing.

Any such test suite can be integrated into CI/CD (Continuous Integration / Continuous Delivery) pipelines of modern development workflows, ensuring that changes are only merged once the functional, procedure-level protocol conformance tests pass.

In Osmocom, for our 2G, 3G and also partially 4G projects, we have extremely positive experience using this approach by implementing test suites in TTCN-3[7], a domain specific language specifically designed by ETSI and ITU for testing protocol stacks. An open source TTCN-3 compiler and runtime environment is available (The Eclipse TITAN[8] project), so that we can run open source tests cases compiled with open source compilers, executing in an open source runtime environment to test open source protocol stack implementations: Anyone can run, extend, execute and modify those tests, against any implementation of the related interfaces.

Furthermore, it is recommended to set up interoperability test-beds where network elements/functions of multiple different implementors are executed against each other.

7 https://www.ttcn-3.org/
8 https://projects.eclipse.org/projects/tools.titan

Development of a related test suite could be a separate challenge itself, and passing a certain number / score of overall tests could be a goal for challenges of actual open 5G implementations.

The open 5G stack market will benefit in the following ways from the availability of an open source functional interface conformance test suite:

- the market becomes more transparent for all participants. Each implementation can be executed against the same set of independently developed tests, superseding the traditional “every projects tests itself and discloses only what it sees fit” approach.
- the tests themselves are accessible to anyone. It's not some “secret sauce” that only the implementor has available internally, or that he has licensed from a third party testsuite vendor, which can only be operated in one installation in-house.
- the amount of duplication of work in implementation-specific test suites can be reduced, improving coverage

In terms of metrics for assessment of proposals, the following recommendations are made:

1. degree of open-ness of the proposal in terms of the software license. Is it proprietary software with just “open interfaces” (lowest possible grade) or an OSI-conformant FOSS license (highest grade)?
2. track record successfully running collaborative open source projects. If key individuals or organizations involved with a proposal have an existing track record of running and/or maintaining non-trivial open source projects
3. how open is the development process for third parties beyond the organization submitting the proposal? What entrance barriers are there to contribution? Is copyright assignment or a CLA[9] required (this introduces a barrier to some potential contributors)? Or is a DCO[10] sufficient (lowest barrier to contribution). Are contribution workflows publicly documented? Does all the communication between developers (even within the same entity) happen on public channels such as mailing lists, forums, project management software, issue trackers, chat rooms?
4. How does the workflow for contributions look like? Is there code review by systems like gerrit?
5. what amount of emphasis does the proposal have on testing? Is testing fully automatized? Manual testing would be lowest grade, with fully automated testing in CI/CD receiving highest grade. Can contributors submit changes and see the test results before changes are merged?

9 Contributor License Agreement, see https://en.wikipedia.org/wiki/Contributor_License_Agreement
10 Developer Certificate of Origin, see https://developercertificate.org/

6. Which programming language is used for the implementation? Is it a language prone to many security related errors like C/C++, or is it a language less susceptible to entire c lasses of security relevant programming errors, such as Rust or Erlang?

II. Incentives and Scope

Testing of various implementation against one shared test suite by its very nature helps interoperability. If everyone has the option of testing against the same test suite, chances are high that the implementations will not only work against that test suite, but also against each other.

Once could also commission the set-up of interop test-beds, once again with automatic testing. This way, nightly builds, release candidates or new versions of Component A from Project X could be automatically tested against Component C of Implementor Z. Changes in test results in terms of pass/fail with log files and associated protocol traces in pcap format should be exported automatically as part of each build and allow investigation of any regressions.

Spearheading the development of open source tests suites for 5G network interfaces would be excellent development support for all elements of an open 5G stack. Going one step further by setting up and operating test beds and automatic / continuous testing would further support those projects to focus on their development, rather than setting up the related CI/CD infrastructure.

III. Timeframe and Infrastructure

The software and hardware infrastructure requirements will depend in a large amount of detail on the scope of the challenge. For example, work on Core Network functions can be implemented completely without any specific hardware, as it is all just software processing protocol messages, API calls and related software development can happen entirely based on test suites/ emulations of the other network elements (like UEs).

The closer the work gets to the RF interface of a base station, the more dependency on hardware is created. Access to related radio hardware is often a problem for independent open source projects, as

1. they may not have any contact to the existing vendors of the related equipment
2. they may be seen as competition to some other offerings of the related vendor
3. open source project require relevant documentation available under terms that enable them to publish the related source code. As all hardware vendors typically work with Non-Disclosure Agreements, a lot of care has to be taken to negotiate very specific wording in those NDAs that enables the open source developers to actually use any of the disclosed information when writing the open source software.

The other hardware that is typically very difficult to access for independent open source projects is expensive RF measurement technology in order to characterize the RF waveforms and their conformity to the relevant specifications. Related measurement devices can easily have a six-digit USD figure attached, putting them out of reach for open source projects that work on tiny or no budgets.

Finally, UE simulation is another important infrastructure that is often missing. Testing with one or a couple of real UE devices is typically not too hard. However, simulating hundreds or more of UEs to generate realistic load on any RAN network element/function typically requires access to very expensive (and hence rare) test equipment.

An interested party like a US Government Agency could be setting up and operating a lab with all of the related equipment, accessible to any open source 5G projects on a free of charge and non-discriminatory basis. Ideally, many tests can be automatized, but manual [remote] access to the lab could be scheduled / granted to individual projects based on their needs/applications.

Last, but not least, easy access to spectrum licenses for R&D purpose is an important factor in enabling development of any cellular system without having to set up expensive and cumbersome RF shielded environments.

Berlin, February 10, 2021,

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