Spectrum Collaboration Challenge

Frequently Asked Questions (FAQ)

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Revision Summary

Section	Revision	Description	Date
Q50 Q32	14	Made question consistent with Q32 Clarified criteria necessary to achieve throughput	11/22/17
Q48 - Q52 Q32	13	Added Clarified how throughput is calculated	11/22/17
Q47	12	Added	11/15/17
Q45 - Q46	11	Added	11/10/17
Q43	10	Updated to reflect antenna pairs	11/3/17
Q43 - Q44	9	Added	11/2/17
Q39 - Q42	8	Added	10/27/17
Q37 - Q38	7	Added	10/19/17
Q32 - Q36	6	Added	10/19/17
Q27 - 31	5	Added	10/2/17
Q25 - Q26	4	Added	9/20/17
Q24	3	Added	8/11/17
Q22 - Q23	2	Added	7/26/17
Q14 - Q21	1	Added	5/25/17
Q1 - Q13	Initial		4/19/17

DARPA Spectrum Collaboration Challenge (SC2)
Frequently Asked Questions
Revision 14

Q52: My CIRN design relies upon open source software, such as the USRP UHD driver, as a key part of the design. If during a scored event (e.g., PE1, PE2 and SCE) an open source component of my design unexpectedly fails, crashes, or otherwise is disruptive to the desired functionality of the radio network, can the match be repeated?

A52: No. Each team is wholly responsibility for the stability of their entire submitted design including any and all open source software used (including the USRP UHD driver).

Q51: In order to qualify for PE1 per Q32, must the *source_node* and *destination_node* fields in the *Performance* message be populated?

A51: No.

Q50: Per Q32, option #1, for PE1, will any contiguous 1 minute period in which a flow achieves the target throughput be accepted as meeting the qualifying criteria?

A50: Yes (throughputs are sliding-window averaged using a 1-minute window with the match interval, specified in the SC2 PE1 Scoring Procedures, as the step size).

Q49: The USRP X310 can create an undesired transmission artifact which manifests as local oscillator leakage (i.e. a "tone") which may appear to be a transmission at a disallowed frequency. Will the unintentional local oscillator (LO) be counted as a transmission at a disallowed frequency?

A49: If each USRP in a competitors CIRN is using the settings recommended below in Q29 – specifically if the USRP is tuned -42 MHz with respect to the scenario center frequency given in *colosseum.ini* – the competitor will not be penalized for the LO appearing at a disallowed frequency. Any other configuration may result in a competitor being assessed penalties for transmission at disallowed frequencies if the magnitude of the LO exceeds the allowed threshold.

Q48: In PE1, will the scenario center frequency change during a match?

A48: No.

Q47: In PE1, are competitors guaranteed to have a period of time at the beginning of a match without traffic?

A47: No.

Q46: To qualify for PE1, per Q32, Is there a minimum and maximum periodicity with which the *Performance* message must be sent?

A46: The *Performance* message must be sent with a minimum periodicity of at least once every 10 seconds, and a maximum periodicity not to exceed 100 times per second.

Q45: To qualify for PE1, per Q32, a CIRN must support at least the *Hello* and *Performance* Collaboration Protocol Messages. Is a CIRN required to provide the *Performance* message as a response to an *InformationalQuery* message, or is unsolicited and periodic transmission of these messages sufficient to qualify?

A45: A CIRN is not required to send the *Performance* message in response to an *InformationalQuery* message. A CIRN must at least send the *Performance* message, in an unsolicited fashion, to all other CIRNs

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Q44: What range of center frequencies will be used for PE1 scenarios?

A44: 900 - 1100 MHz.

Q43: How many antennas will be available per SRN in PE1 scenarios?

A43: 2 receive and 2 transmit antennas.

Q42: Are packets from the IP Traffic Generator fragmented according to the maximum transmission unit (MTU) of the */dev/tr0* interface?

A42: Yes.

Q41: During PE1, what is the minimum frequency bandwidth available for a CIRN to transmit over without incurring a penalty for transmitting on a disallowed frequency?

A41: 5 MHz.

Q40: How is average latency computed for a match scoring interval in which not all packets are delivered?

A40: All packets with delay greater than the maximum possible delay, noted as L_C^{MAX} in the Scoring Procedures, are assigned delay L_C^{MAX} prior to computing the average. This includes dropped packets (i.e. those with infinite delay).

Q39: In order to qualify for PE1, is there a latency requirement a CIRN must meet?

A39: The throughput computation will only include traffic delivered up to 10 seconds after the 1-minute evaluation period (see Q32). There is no specified latency which must be achieved.

Q38: How many submissions per team will DARPA evaluate for PE1?

A38: A maximum of two submissions per team will be evaluated. One evaluation will be conducted following the initial submission deadline of 6:00AM US Eastern Time November 20th 2017, and one evaluation will be conducted after the final submission deadline of 6:00 AM US Eastern Time November 29th.

Q37: If a team makes two PE1 submissions, which will be used for PE1?

A37: The more recent of the two submissions which successfully qualifies per the criteria in Q32 will be used for PE1.

Q36: For PE1, how will the power spectral density (PSD) in dBFs (decibels relative to Full-scale) be computed to assess transmission at disallowed frequencies?

A36: The following shows the computation of the PSD for a complex-sampled signal x, normalized by the maximum integer value that can be produced by the analog-to-digital converter such that the largest possible magnitude of x is one, i.e. $\max(\mathrm{abs}(x)) = 1$.

$$PSD(x) = 20\log_{10}(\mathrm{abs}(\mathrm{fft}(x)) - 20\log_{10}(N) - 10\log_{10}(f_s)$$

Where N is the number of points in the Fourier transform (indicated as *fft*), and $f_s = 100 \times 10^6$ is the sampling rate.

Q35: Will PE1 matches contain an unscored training period at the beginning of a match?

A35: No.

Q34: If my team's design successfully qualifies for PE1, but does not place among the top scoring teams, do I need to complete the Phase 2 Entrance Hurdle in order to remain in the competition?

A34: No. All teams whose designs qualify for PE1 are automatically eligible to participate in Phase 2 regardless of the outcome of PE1.

Q33: In order to qualify to participate in PE1, when and how must final Collaborative Intelligent Radio Network designs be submitted?

A33: Initial CIRN designs are due by 6:00AM US Eastern Time November 20th 2017. Finalized designs are due by 6:00 AM US Eastern Time November 29th. Submissions must be compliant with the following criteria to qualify:

- A single radio container that works in batch mode with an MD5 hash of the container image
- The image is named pe1.tar.gz, and is located on your NAS shared at /share/nas/<team_name>/pe1/pe1.tar.gz
- You provide an md5 hash of the submitted image at /share/nas/<team_name>/pe1/pe1.md5 (This must be an ***md5*** hash)
- You provide a ***SINGLE*** modem configuration file for all radios submitted at /share/nas/<team_name>/pe1/config/radio.conf

A complete and correct submission will consist of the following folders and files

- /share/nas/<teamname>/pe1/
- /share/nas/<teamname>/pe1/pe1.tar.gz
- /share/nas/<teamname>/pe1/pe1.md5
- /share/nas/<teamname>/pe1/config/
- /share/nas/<teamname>/pe1/config/radio.conf
- /share/nas/<teamname>/pe1/config/batch.json

Q32: Per Section 3.2.1 of the SC2 Rules Document, what performance must my CIRN achieve in order to qualify to participate in PE1?

A32: In order for a submitted CIRN design to qualify to participate in PE1, the 5-node CIRN must achieve an average data rate of 1.0 Mbps (of application layer payload data, excluding overhead) under either of the following conditions:

1. Each radio link individually achieves an average 1.0 Mbps over any 1 minute period
2. All radio links achieve an average of 1.0Mbps over the same 1 minute period

This criteria will be tested in the following configuration:

- 4 IP traffic flows between 5 radios nodes labeled A-E such that IP traffic flows as follows:
  - Flow 1: A->B, UDP Traffic of at least 1Mbps
  - Flow 2: B->C, UDP Traffic of at least 1Mbps
  - Flow 3: C->D, UDP Traffic of at least 1Mbps
  - Flow 4: D->E, UDP Traffic of at least 1Mbps
- At least 30 dB SNR is present over 6 MHz of allowed bandwidth (submissions which transmit outside the 6MHz of bandwidth may be deemed ineligible)

Additionally, the CIRN must properly register with the Collaboration Protocol Server, and support at least the following Collaboration Protocol Messages: *Hello* and *Performance (*with at least one of *scalar_performance, bit_error_rate, or frame_loss_rate* supported). The *Performance* message sub-field(s) must be filled with meaningful content; random or constant-values which do not reflect the achieved throughput may be deemed ineligible.

Q31: Is a CIRN allowed to deliver packets and packet fragments out of order to improve its score?

A31: Yes.

Q30: Do the training bots provided by DARPA maintain the same performance during tournament events (e.g. Scrimmages and scored events PE1, PE2 and SCE) if used as a competitor submission?

A30: The training bots are designed in such a way that they will not operate successfully during tournament events.

Q29: Are competitors wholly responsible for selecting all USRP settings, such as amplifier gain?

A29: Yes, each team's CIRN software is responsible for setting all USRP settings. For convenience, a list of recommended USRP settings has been provided by the USRP hardware manufacturer (National Instruments) and is available at the following location:

http://sc2colosseum.pbworks.com/w/page/120410898/Optimizing%20SRN%20USRP%20Performance

Q28: For PE1, will frequencies be disallowed at the onset or during the course of a match?

A28: At the onset.

Q27: For PE1, how many disallowed frequency bands must a CIRN obey?

A27: Two. One disallowed frequency band starting at 0 Hz and extending to the lower most allowed frequency: $[0\ Hz, f_{min}\ Hz)$, and one disallowed frequency band starting at the upper most allowed frequency and extending to infinity $(f_{max}\ Hz, \infty\ Hz)$.

Q26: To compute PE1 scores, will the latency of a fragmented IP packet be computed only after all fragments are successfully received?

A26: Yes.

Q25: During PE1, what is the maximum available frequency bandwidth a CIRN may transmit over without incurring a penalty for transmitting on a disallowed frequency?

A25: 20 MHz.

Q24: Are the emulated receive antennas guaranteed to be perfectly isolated from the transmit antennas of the same radio node?

A24: No.

Q23: During PE1, for non-degraded conditions, what nominal gateway-to-gateway bandwidth and latency can be expected for the collaboration channel?

A23: A minimum average bandwidth of 1 Mbps and a maximum average round-trip latency of 50ms can be expected under nominal, non-degraded conditions.

Q22: During PE1, how often will the collaboration channel experience degraded conditions which do not meet the definition of nominal?

A22: No more than 10% of the available points that can be scored will occur during periods of time when the collaboration channel operates under degraded conditions.

Q21: Are incumbent network radios guaranteed to be fixed-position?

A21: No.

Q20: For PE1, what is the maximum speed of mobile nodes?

A20: The maximum speed for mobile nodes is 50 mph.

Q19: For PE1, How will scenario specific parameters such as bandwidth, Effective Isotropic Radiated Power (EIRP), and center frequency be communicated to our CIRNs?

A19: All scenario specific parameters are contained in the RadioAPI Colosseum config file.

Q18: What center frequency range will scenarios models?

A18: 10 MHz - 6 GHz.

Q17: During scrimmages and competition events (PE1, PE2, and SCE), will our container have access to the internet?

A17: No.

Q16: Will teams know which SRNs they will use in advance of the PE1 competition? How can we identify the specific radio node our container resides on at startup?

A16: No. SRN nodes can be identified by inspecting the */etc/hostname* file.

Q15: For Phase 1 scrimmages and competition (PE1), how many containers can I deliver?

A15: One.

Q14: Will the full Colosseum bandwidth be available in every scenario?

A14: No.

Q13: Do the eligibility requirements in the SC2 Rules Section 5 permit a non-US team comprised of non-US citizens to participate in the Spectrum Collaboration Challenge?

A13: Yes.

Q12: My approach includes techniques that require the use of hardware other than the Standard Radio Node. Can I provide my own hardware?

A12: No. (see SC2 System Specification Document).

Q11: Can I make use of International Traffic in Arms Regulated (ITAR) software in my Collaborative Intelligent Radio Network (CIRN)?

A11: No.

Q10: Is MIMO enabled (allowed) in the SRN nodes during competition? Is it a requirement?

A10: MIMO is enabled and allowed during competition. Colosseum is designed to support 2 TX and 2 RX “antennas” (2x2 MIMO) per SRN. CIRN designs may choose to take advantage of the provided multiple “antenna” configuration or may choose to disregard the second antenna input and output.

Q9: Will Collaborative Intelligent Radio Networks (CIRNs) be given their current score or other networks' scores by Colosseum infrastructure during PE1 so they can adapt online?

A9: No. CIRNs may choose to share relevant performance metrics with each other through the Collaboration Protocol however.

Q8: Will SRNs be given GPS-like localization information?

A8: SRNs may receive localization information periodically throughout the match. The information's accuracy will reflect modeled conditions in the scenario. For example, localization data provided to indoor nodes may have increased uncertainty compared to that of outdoor nodes.

Q7: During the competition, can we (humans) provide control input to our nodes?

A7: No. CIRNs must be fully autonomous.

Q6: May teams add or change members as the competition evolves through the phases?

A6: Yes, with the following restrictions:

1) A team may remove members at any point in the competition at the sole discretion of the team.

2) A team may add wholly new members at any point at the sole discretion of the team. Wholly new members are those that have not previously participated on any SC2 team.

3) A team may only add new team members who previously participated on another SC2 team under one of the following conditions:

- The new team member participated as a member of another team in a previous phase of SC2, and is not has not participated in the current phase.
- The new team member participated as a member of another team in a previous phase, and is changing teams during the allowed grace period, January 1 – March 31 of the next phase.
- The new team member participated as a member of another team which has formally disbanded or otherwise withdrawn from the competition.

4) Teams may not add team members who currently or previously participated as part of the SC2 DARPA team.

5) All team membership changes must be registered with DARPA SC2 Team via email to sc2@darpa.mil.

6) The registered team lead is the only person authorized to make membership changes.

Q5: Will our CIRN be told how long a match will last?

A5: No. Information about match duration will not be provided to CIRNs.

Q4: Can gateway nodes be assumed to be stationary since they have a wired backhaul?

A4: No. The use of the term "wired network" in the SC2 Rules Document (Section 2.1) refers to the fact that no RF waveform is required for the gateway to use its second interface to collaborate with other CIRN gateways. The modeled internet connection statistics (such as throughput and latency) may model wired or wireless internet characteristics.

Q3: Can teams choose which network node is the gateway?

A3: No.

Q2: Can teams control the location of any of their nodes?

A2: No.

Q1: Will teams be allowed to practice with one another on Colosseum outside of scrimmages or match events?

A1: No. Inter-team practices outside of scheduled scrimmage and match events are not allowed. Any attempt to organize such events may be considered collusion per the SC2 Rules Section 5, and may lead to disqualification.