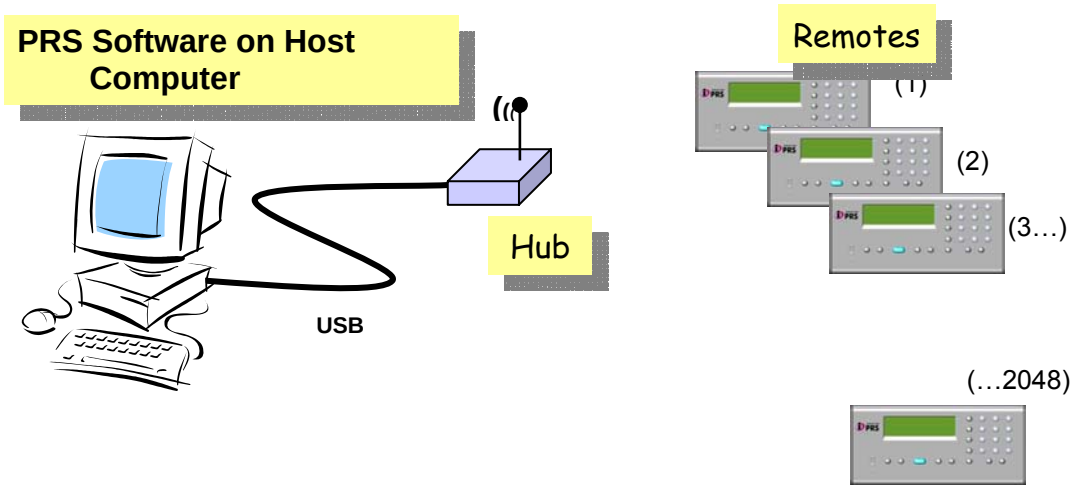
Operational/Technical Description
PRS-RF Hub



The system consists of the following items:

- 1 to 2048 Remotes (max) per Hub. Each Remote to include an LCD display and keypad for user entry of data. The LCD display is used to show the students response and status information regarding the transmission. The LCD display will not be used to show questions.
- 1 or more Hubs connected to the host computer via USB, a maximum of 4.

The system is designed so that the Hub controls the communications with the plurality of Remotes.

❖ Upon connection to the PC and start of the PRS application software, the Hub will become active. The PRS software will automatically detect the attached Hub. Upon detection of the attached Hub the software will read the Hub radio ID and prompt the instructor to provide the Hub with System type (Open or Closed), an identity for that class, (the Class ID), maximum class size, and whether it is a Classroom Test or a Self Paced Test.

❖ The Hub will scan all available frequencies, PN codes and data rates to determine which class channels and data channels are most appropriate for communication. This scanning is basically determining the level of RF interference within the environment so that the system can configure itself for optimal performance. Once clear channels are acquired, the Hub will provide the configuration information back to the Host Computer for diagnostic purposes. Information such as RF activity by channel should be provided if possible. A diagnostic mode should be supported as well that allows the Hub to simply scan and provide a snapshot of what it is seeing in the way of RF communications within the environment.

❖ The system shall support either a single or a multiple classroom environment. As such, it is likely that Hubs will be within range of each other. It may also be possible

for Hubs to be out of range of each other, but that certain Remotes may be able to see both Hubs. This would be the case for large classrooms set back to back. Students at the back of the room could possibly see both Hubs. It will be important in the system architecture to ensure students are responding to the proper Hub in this scenario.

- Each Hub has to have a unique identification to support addressing. Addressing for the Hubs is generated by the PRS software in a closed system, so that Hub devices can be swapped out without requiring new binding. As such, involvement of the system users is required to guarantee that Hub IDs will be unique. GTCO CalComp will establish a scheme that provides a high likelihood of uniqueness, but not absolute.
- For Open systems, the Hub ID will default to the lower 16 bits of the Hub Radio ID, however users can override and set a specific Hub ID if desired. In Open Systems, each of the Remotes has to be re-assigned a Remote ID, so there is no real value in logically assigning a Hub ID at this time. It simply places more burden on the Instructor so ensure that it is unique in an open environment.

❖ Once the Hub is set up and broadcasting it's presence, identity, system type, test type and channel control information, it will allow Remotes to begin binding (or linking) to it if it is a student owned model. This binding provides the student Remotes with a temporary address (Remote ID) that will define in which time slot and group it is eligible to send it's response data. In a student shared model, the linking is not required for the assignment of a temporary address since a semi-permanent address will be defined.

➢ Remotes only transmit during one of two times 1) a Bind request, 2) in their given time slot for data. This ensures that Remotes are not generating unwanted interference. For example, a student cannot simply type in a value and hit send and have the Remote transmit data asynchronously. The Remote will hold that data in an output buffer waiting on it's time slot to become available.

➢ The Remotes are typically off or asleep much of the time. In the Student-Owned model, when arriving in class, the students will turn them on and begin to link into the class. It is likely that some percentage of students will not try to link to the Hub until a question is started, as such, a binding/link structure within the question needs to be supported. It is anticipated that the Remotes will be used in multiple different classes for higher education since the Remotes are student owned, however in a K-12 environment, the Remotes stay with a room and the students therefore share them. The PRS-RF system needs to support both implementations. As such, the Remote will contain a field that supports semi-permanent storage of a Student ID.

- For the Open System (Student Owned model), the Student ID in the Remote will match the individual student's ID#. In this manner, the Remote can be configured one time during the ownership by that student and used in multiple courses over the life of the Remote. This is the Known Student response.
    - To support the anonymous response, the Student ID will be ignored and not required. In this manner, Remotes can be used without any

configuration at all to collect anonymous responses from any group of students.

- For the Closed System (Student Shared model), the Student ID in the Remote can be set up to be a logical student ID. As in the case of a K-12 environment where the instructor sets up a system with numbers 01-32 and students in a particular class use those matching numbers in each class. This allows the instructor to use a small response map with a two digit ID if desired, and if a Remote is lost or damaged, to program a new one to that missing Logical Student ID. Correlation of the Logical Student ID and the Actual Student ID has to be done at the software level.

- In the Student Shared model, a tighter binding should be supported. In this case, since the Remotes are not going to be dynamically moving between Hubs, the management of unique Remote IDs can be placed on the instructor(s) rather than the system. In this scenario, using the Logical Student ID as the Remote ID is feasible and removes the requirement that students link into the Hub as a first step. This can be done if the Remotes are locked to a particular Hub ID through a setup feature in the Remote. In a student shared model, the Remotes would simply scan through the channels to find the one which has their Hub ID being broadcast. Semi-permanent system storage of the last channel, PN Code, Data Rate used is maintained in the Remote to speed the acquisition of the Hub channel.

- For the Classroom-Test mode, the Remote has no knowledge of the question type. This allows the Remotes to simply send data (up to 12 characters) in an open fashion to the Hub device. The response typed into the Remote is displayed after the response has been sent so the student has a visual indication after the fact. After being sent, pressing any key, especially ◄ will clear the entire response and begin the entry of a new response value.

- For the Self-Paced-Test mode, the Remote will need to know that it is a self paced test in order to display question numbers for students to scroll through and respond to questions in non-sequential order. In self paced mode, the Remote will transition through Navigation, Entry and Display modes to support the movement between questions, data entry and display. Navigation mode can only be entered during self paced mode when there is no data in the response line and the up/down arrows are hit.

- In self paced mode, student responses are sent to the Hub with each question, i.e. the data is not stored on the unit and sent in a bulk fashion. This provides the Hub, and therefore the PRS software with the ability to see where students are at in their question responses
  - The Remote does not need to know how many questions are in a self paced test. Since the management is being done at the Hub and the student has a test in front of them, they will know how many questions are in the test. The Self Paced test mode starts with the student entering the Test number from the physical test. It then goes to Question 01 and goes through a possible Question 99.

        - A dynamic instructor window would be nice for the software to allow the instructor to monitor by student where they are in the self paced test mode and how well they are doing, if an automatic calculation is provided.
    - In self paced test mode, the response should be maintained in memory for review purposes. When the unit is powered off, the memory (101 x 12 characters) would become available for reuse. At the beginning of Self Test mode the prior memory needs to be cleaned to avoid having remnants of the prior self-paced test.

Hub Details

The Hub will be USB CDC device. It will look like a virtual serial port to the host application, which is supported in Windows and Mac environments.

Power Source: 9V external power supply
Internal Power: 5V regulator @ 200mA max.
Interface: USB CDC
Radio: Cypress WUSB (2.4 GHz)
Antenna: Two chip type antennas are used (1 for TX and 1 for RX).
RF Range: 150 feet (50m) in free space
RF Frequency Range: 2.402 GHz to 2.479 GHz
Channel 2 is 2.402 GHz
…
Channel 79 is 2.479 GHz
The channels are separated from each other by 1 MHz intervals.
Channels will be allocated to two different functions 1) providing Class information, typically the Hub communications to the Remotes and 2) Data, typically Remote communications to the Hub.

Class
The Class information function will use 1 of 13 Channels – Channels 2, 8, 14, 20, 26, 32, 38, 44, 50, 56, 62, 68, 74. The Hub will scan the Class channels and determine which of the 13 has the lowest RF activity and utilize these for communications to reduce interference with other systems.

Each class channel can use 1 of 2 PN codes. Selection of the PN code is done by the Hub as it scans the class channels and determines which channel and PN code provide the best performance.

Each class channel can use a low speed 15.625kbs data rate for the most reliable communications. As such, no selection of the communications speed is needed.

Class channels are transmitted from the Hub to the plurality of Remotes. They provide one way communication between the Hub and Remote to indicate data which can include

combinations of the following: Command, Hub ID, Class ID, Test Type, Audience Type, PN code, Data channels, class channels, data rates. Where the Command is Bind Request, Open Question, etc… Additionally, the Hub will also acknowledge the Remote Bind with an ACKnowledgement on the class channel.

Data

The Data function will use 1 of 65 possible Channels (the other 65 of the 78 total channels not used by the class function)

Each Data channel can use 1 of 48 PN codes for 15.625Kbs rates and 1 of 8 PN codes for the 31.25Kbs and 62.5Kbs data rates. Each Data channel can use 1 of 3 commutations speeds (15.625kbs 31.25Kbs or 62.5kbs)

Hub Addressing

The Hub will contain a Radio ID, a 32 bit value in the RF chip itself which provides a somewhat unique address. The lower 16 bits of the Radio ID will by default be used as the Hub address (Hub ID) for communications with the Remotes. This provides a high degree of uniqueness, but again, not guaranteed.

The Hub ID can also be set dynamically by software. A warning will appear when the instructor starts PRS and the Hub ID has been logically defined by the instructor. The warning will be: *"Hub ID has been user defined, please ensure there are no Hubs in operation with 300 M with the same Hub ID for proper operation"*. The Hub should also scan class channels occasionally for other Hubs that could be broadcasting within range. If a Hub reports active adjacent Hubs to the PRS software and they have the same ID, then a warning is generated for the instructor. The dynamic Hub ID allows the instructor in the closed system to select any Hub for operation with their class, so if a Hub is swapped or replaced, there is no disruption in the closed system and all the Remotes to not have to be "re-programmed".

Status LED

Fast flash if no USB connections
Slower flash when scan for channels
On when class in running