Requirements for Year 2006 TCU.

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This document outlines the requirements for an upgraded STAR Trigger Control Unit (TCU).

Notable similarities to previous version:

1. The TCD interface remains identical
2. The DSM / Detector live interface remains identical (except for the addition of more input signals)
3. The token handling logic remains identical
4. The VME interface remains as similar as possible to the existing version, given the modifications due to hardware & firmware changes.

Notable changes from previous version:

1. Change: **Preceded / Followed** - No longer require preceded / followed logic.

2. Change: **Limitations** – The following limitations will be increased
   * 16 DSM inputs increased to 128 DSM inputs
   * 8 detector groups increased to 16 detector live inputs
   * Prescale value range increased to 32 bits

3. Change: **Logic** – The following quantities will be organized around the trigger rather than around arbitrary entries in a lookup table (PW or TW)
   * Prescales
   * Detector requests
   * DSM bit and detector live requirements
   * The action word
   * Event counters

TCU Requirements

1. Requirement: **Format** - The TCU must be a 9U VME board.
   Justification: Easy integration with existing DSM and TCD hardware.

2. Requirement: **Speed** - The TCU must accept input data and produce a trigger decision every tick of the RHIC clock.
   Justification: Every RHIC clock represents a possible collision.

3. Requirement: **DSM Data** - The TCU must be able to accept up to 128 physics input bits from the DSM tree.

Justification: To removing existing constraints on what triggers may be implemented and to support detector and trigger upgrades for years to come.

4. Requirement: **Detector Status** - The TCU must accept up to 16 independent input bits representing each of the non-trigger detector system's LIVE/BUSY status.
   Justification: No trigger may be issued to any detector while it is dead.

5. Requirement: **Supported Triggers** – The TCU must support 128 simultaneous running triggers.
   Justification: To support star operations.

6. Requirement: **Trigger Independence** – The behavior of a trigger should be fully defined by the DSM input bits presented to the TCU when the detectors requested for the trigger is live. This criterion must remain true for each trigger individually, no matter how many, or which other triggers are specified.
   Justification: This is necessary to ensure unbiased triggering.

7. Requirement: **Detector Requests** – If a trigger is fired, each detector in the trigger's detector request must be fired. Additional detectors may also fire, if requested by other satisfied triggers.
   Justification: To support triggers with differing detector requirements

8. Requirement: **Internal BUSY** - The TCU must generate a short internal BUSY state for user-specified detectors to cover the time it takes between the issuing of the trigger and the raising of the detector busy signal.
   Justification: No trigger may be issued to any detector while it is dead.

9. Requirement: **Decision** - The TCU must generate a trigger decision each bunch crossing, depending on only the values of the 128 DSM bits, the 16 detector bits, and the internal state and configuration of the TCU.
   Justification: This is the only data that is available to the TCU on which to base a decision.

10. Requirement: **Token Based Resource Management** - The TCU will manage the resources of the entire trigger system, by tagging events with one of 4095 tokens. A token may not be reused until the event has exited the trigger system.
    Justification: Existing trigger protocols must be maintained.

11. Requirement: **Prescale** - The TCU must be capable of prescaling each defined trigger independently. The prescale range must be large enough to scale the rhic clock to less than .1 Hz.
    Justification: The only way to control the detector deadtime is to manage the L0 trigger rate.

12. Requirement: **Detector Selection** - The TCU must be able to configure triggers which fire any subset of detectors. The set of detectors fired any bunch crossing must be the logical "or" of the detector request of each satisfied trigger.
    Justification: The detector requirements are part of the specification of a trigger.

13. Requirement: **Notification** - When the TCU issues a trigger it must distribute information to the trigger system. This includes providing the trigger command, daq command and token to the TCD of each triggered detector. It also includes making the same information, as well as a list of triggers and detectors fired, and the current DSM buffer address available over VME so that other components may be notified via the trigger network.
    Justification: The existing trigger protocol must be obeyed.

14. Requirement: **Halt** – A bullet proof mechanism for ensuring that the DSM data read out by the DSM CPU's is not stale must be implemented.
    Justification: Data is saved in the DSM circular input buffers for 7 ms after it is written. A scheme must be in place to ensure that the date is not stale.

15. Requirement: **Abort and Accept** - A mechanism must be provided to issue aborts and accepts for events in the system via the VME interface.
    Justification: The abort and accept decisions are made other trigger components.

16. Requirement: **Null Event** - If the current event is not triggered, and there are no aborts to be issued, the TCU must actively send zeros to all the non-trigger detectors.
    Justification: If the TCU does not actively send zeros, the detectors may fire erroneously.

17. Requirement: **Counters** – The TCU must count at a minimum the following quantities:
    * Bunch Crossings
    * Detector Live for each detector
    * Physics Satisfied for each trigger
    * Combined detector live for each trigger
    * Events triggered for each trigger
    * Events triggered for each possible two trigger combination

    The TCU Counters must be 40 bit counters to avoid overflow. One must be able to read the counters over the VME interface while the TCU is in run mode
    Justification: The TCU counters should be able to take over the full functionality of the "Tonko Scalers" scaler board.

18. Requirement: **VME Specification** – Two VME issues should be repaired:
    * Polling the event fifo during VME backdown downloads should not lock the crate
    * The TCU should respond unconditionally to the SYSreset line by performing a power-on reset.

Justification: To eliminate the necessity to power-cycle the VME crate on errors.