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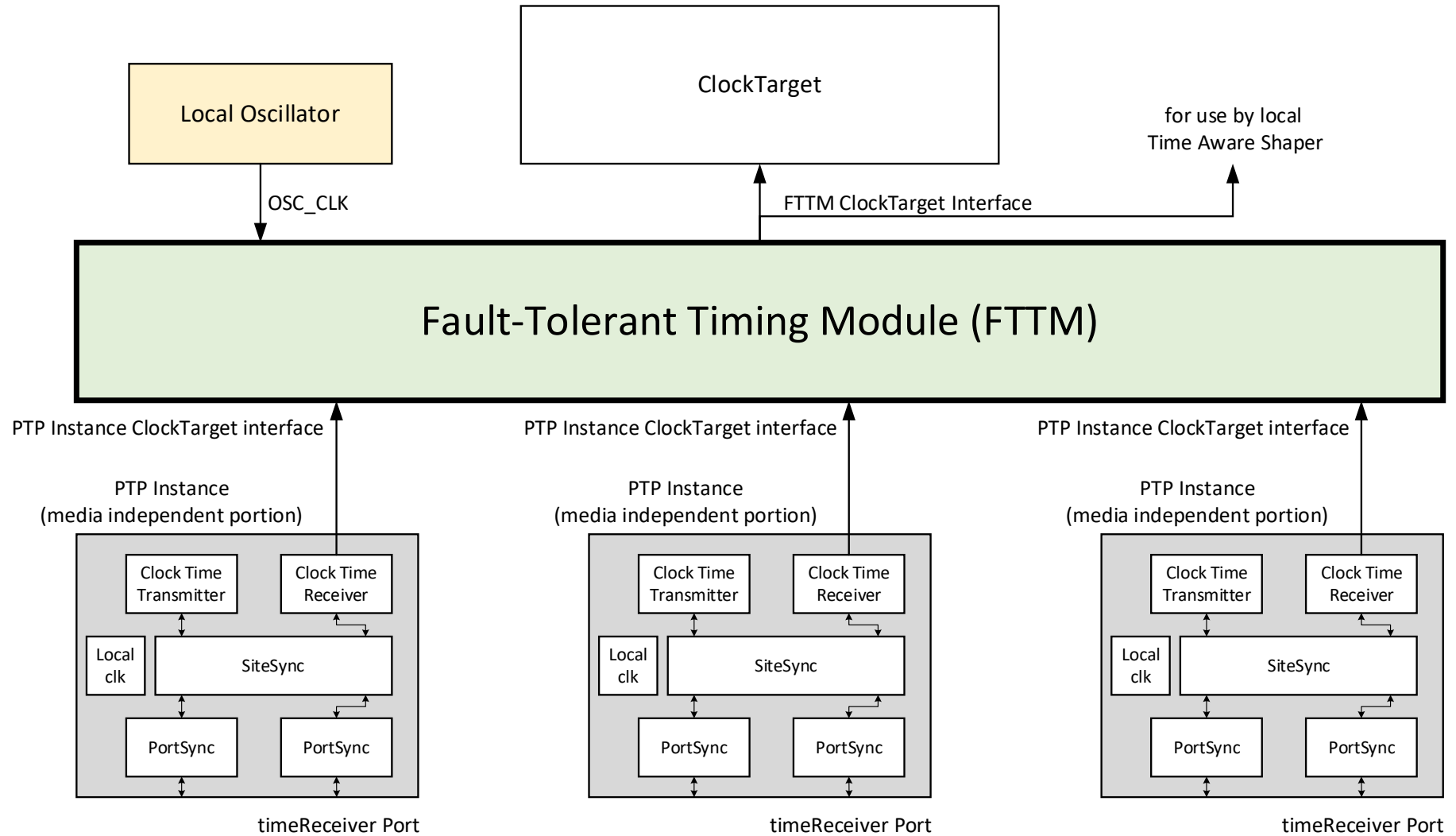
# FTTM Contribution for 802.1DP

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# Outline

1. Concepts
2. Functional description
3. Default algorithms
4. Future work for FTTM

# FTTM



- FTTM sits between PTP End Instances and a ClockTarget
- ClockTarget application interfaces transfer time towards the ClockTarget

# Concepts

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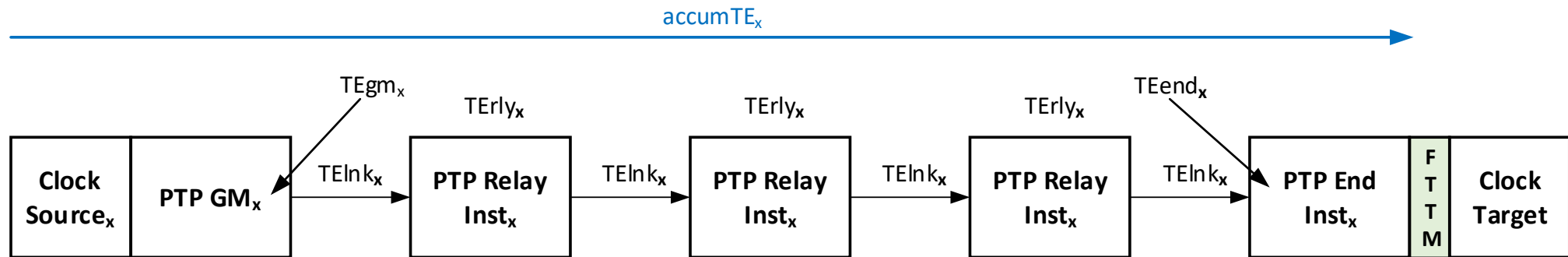
- Time agreement generation and preservation
  - “...the process by which multiple time source nodes (GMs) come to an agreement on the time and maintain that agreement in the presence of both faults and oscillator drift”
  - This function is out of scope of P802.1DP
- Time agreement propagation
  - “...the process of propagating the time established by time agreement...”
  - This function is performed using IEEE Std 802.1AS

# Concepts

- Dependent domains
  - Share a common influencer, which can cause a common mode fault
  - Can improve availability of the time function
  - Cannot (on their own) provide integrity for the time function
  - Can be identified by:
    - Sharing the same domainNumber value
    - Sharing the same gmTimeBaseIndicator value
    - Being defined as dependent by a management function (out of scope of the standard)
- Independent domains
  - Do not share any common influencers
  - Can improve availability of the time function
  - Can provide integrity for the time function

# Concepts

- Time error accumulation
  - Time error components in PTP time agreement propagation path are used to define thresholds that are used by FTTM algorithms

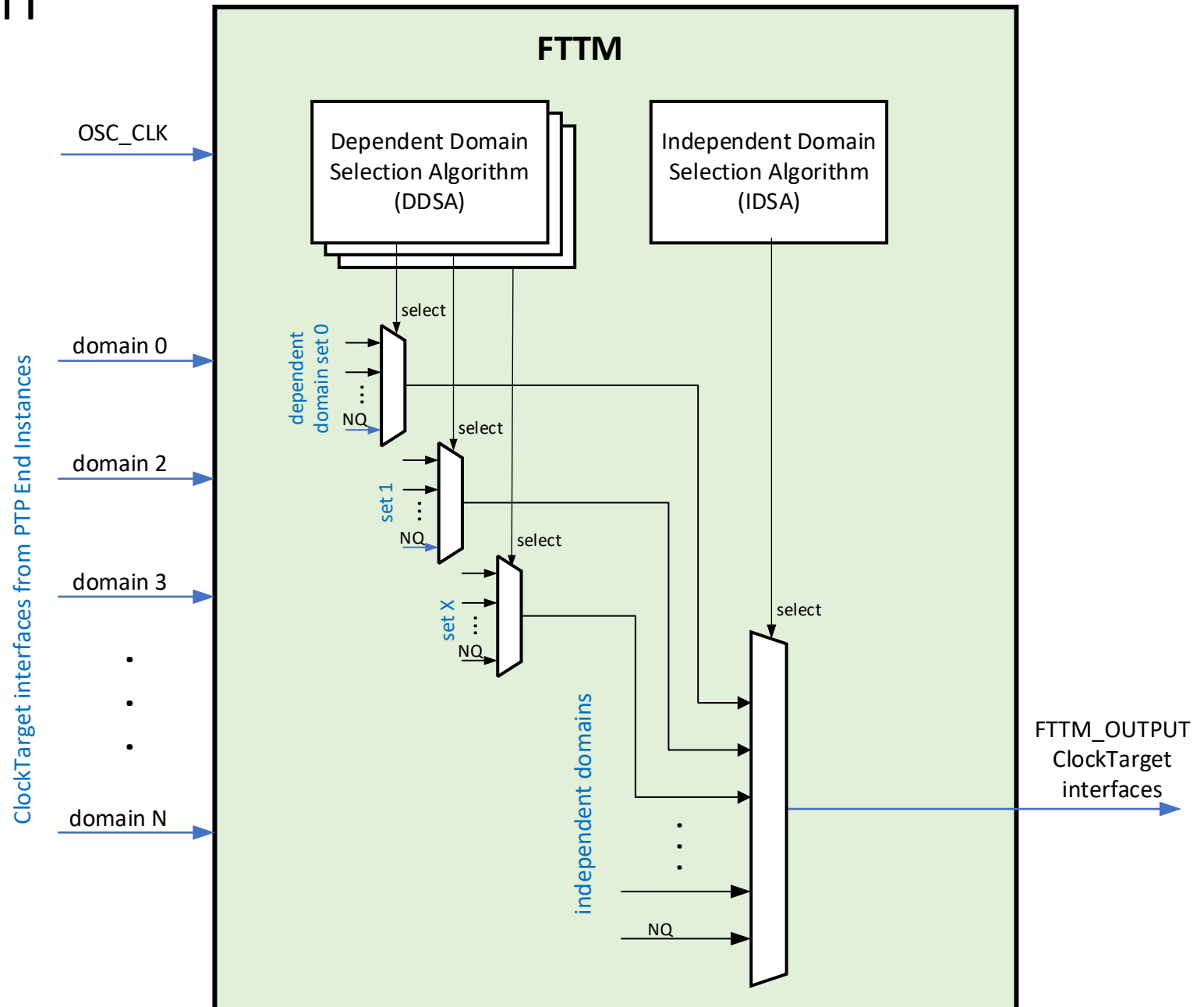


# Functional Description



# Functional Diagram

- FTTM selects between input domains to produce an output domain, where each domain is represented by a ClockTarget interface
  - “NQ” represents an unqualified domain
- DDSA selects between domains that share a dependence
  - Output feeds the IDSA as an independent domain
  - Multiple DDSAs can be present in a FTTM
- IDSA selects between independent domains
  - Output becomes the FTTM’s output



# ClockTarget Interfaces

- Timing application interface types that provide time to a ClockTarget are defined in clause 9 of IEEE Std 802.1AS
  - ClockTargetEventCapture *“tell me the current time”*
  - ClockTargetTriggerGenerate *“tell me when the time = T”*
  - ClockTargetClockGenerator *“tell me the time periodically, starting at time = T”*
  - Other types are possible (per IEEE Std 802.1AS)
- Any one of the above interface types can be chosen for an input domain to the FTTM and for the FTTM’s output domain
- ClockTargetPhaseDiscontinuity interface provides additional information about discontinuities and can be included with the input and output interfaces

# Dependent Domain Selection Algorithm (DDSA)

- DDSA selects between input domains that have a common dependence
- If no input domain can be determined to be trusted, then the “not qualified” (NQ) domain is selected
- DDSA’s output domain is treated as an independent domain by the Independent Domain Selection Algorithm (IDSA)

Trusted: domain passes a specified criteria that is within a safe bound of a non-faulty domain and is thus safe to use

# Independent Domain Selection Algorithm (IDSA)

- IDSA selects between input domains that are independent (have no common influencer)
- If no input domain can be determined to be trusted, then the NQ domain is selected
- IDSA's output domain is the FTTM's output domain

## Not qualified (NQ) domain

- NQ domain has its gmPresent and isSynced status set to FALSE, indicating that the domain does not contain a trusted time

# Default Algorithms

# Common parameters

- **maxAccumTE<sub>x</sub>**

- “...the maximum non-faulty accumulated time error magnitude for domain x, from its GM (TEgm), through all intermediate PTP Relay Instances (TERly) and the corresponding links (TElnk), to the PTP End Instance (TEend) that is connected to the FTTM”

$$\text{maxAccumTE}_x = \max(|\text{TEgm}_x|) + \sum \max(|\text{TERly}_x|) + \sum \max(|\text{TElnk}_x|) + \max(|\text{TEend}_x|)$$

- **maxAgms<sub>xy</sub>**

- “...maximum accepted time skew magnitude between two non-faulty PTP GMs, GM<sub>x</sub> and GM<sub>y</sub>”

$$\text{maxAgms}_{xy} = \max(|\text{TEgm}_x|) + \max(|\text{TEgm}_y|)$$

- **maxAps<sub>xy</sub>**

- “...maximum accepted propagation skew magnitude between the time of two non-faulty domains, x and y”

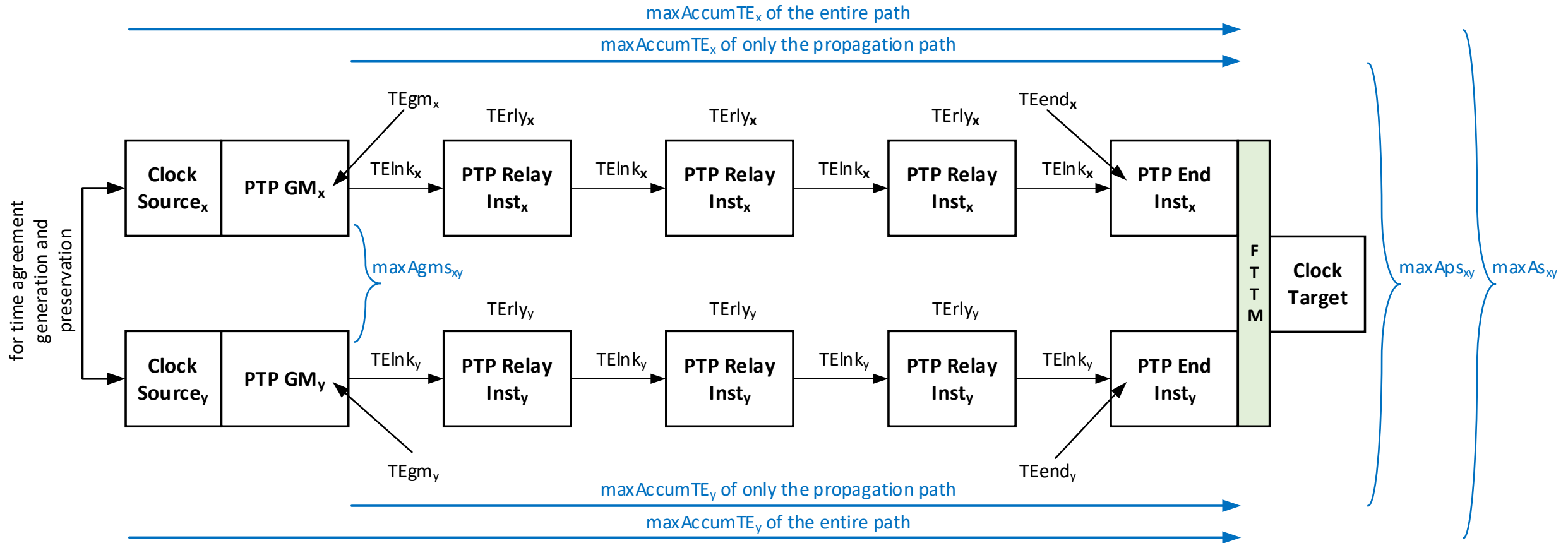
$$\text{maxAps}_{xy} = \sum \max(|\text{TERly}_x|) + \sum \max(|\text{TElnk}_x|) + \max(|\text{TEend}_x|) + \sum \max(|\text{TERly}_y|) + \sum \max(|\text{TElnk}_y|) + \max(|\text{TEend}_y|)$$

- **maxAs<sub>xy</sub>**

- “...maximum accepted skew magnitude between the time of two non-faulty domains, x and y”

$$\begin{aligned} \text{maxAs}_{xy} &= \text{maxAgms}_{xy} + \text{maxAps}_{xy} \\ &= \text{maxAccumTE}_x + \text{maxAccumTE}_y \end{aligned}$$

# Illustration of common parameters





# Common parameters

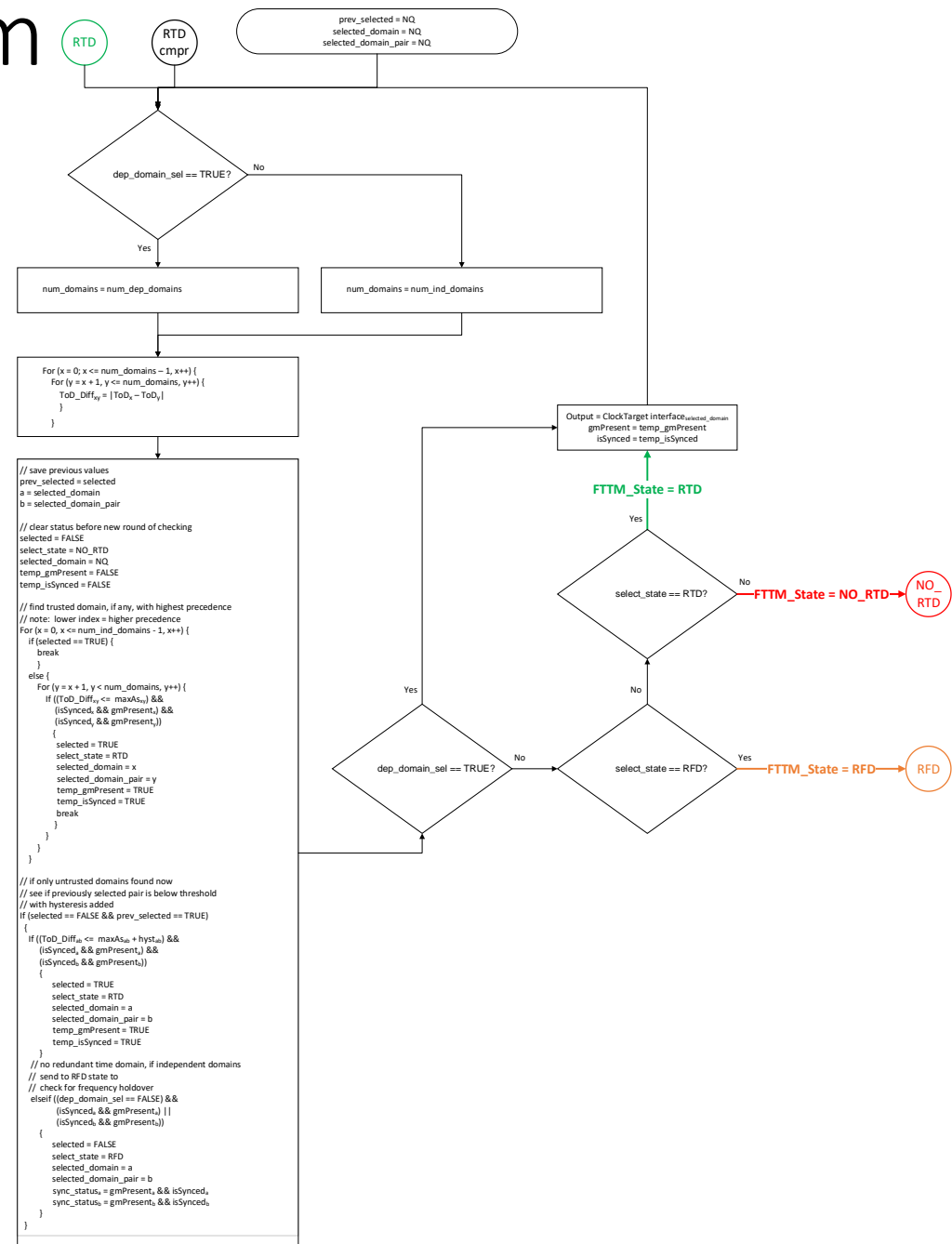
- **hyst<sub>xy</sub>**
  - “...hysteresis magnitude for the time skew of two non-faulty domains, x and y”
- **ToD<sub>x</sub>**
  - “...the time of domain x at a given instant”
- **num\_ind\_domains**
  - “... equal to one less than the number of independent domains that the IDSA has to process”
- **num\_dep\_domains**
  - “... unique to each dependent-pair selection algorithm instance and is equal to one less than the number of dependent domains that the particular dependent-pair selection algorithm has to process”
- **dep\_domain\_sel**
  - “... identifies whether the algorithm is used for selecting between dependent domains or independent domains”

# Default DDSA algorithms

- DDSA can use the following default algorithms:
  - closest-pair selection
  - mid-value selection

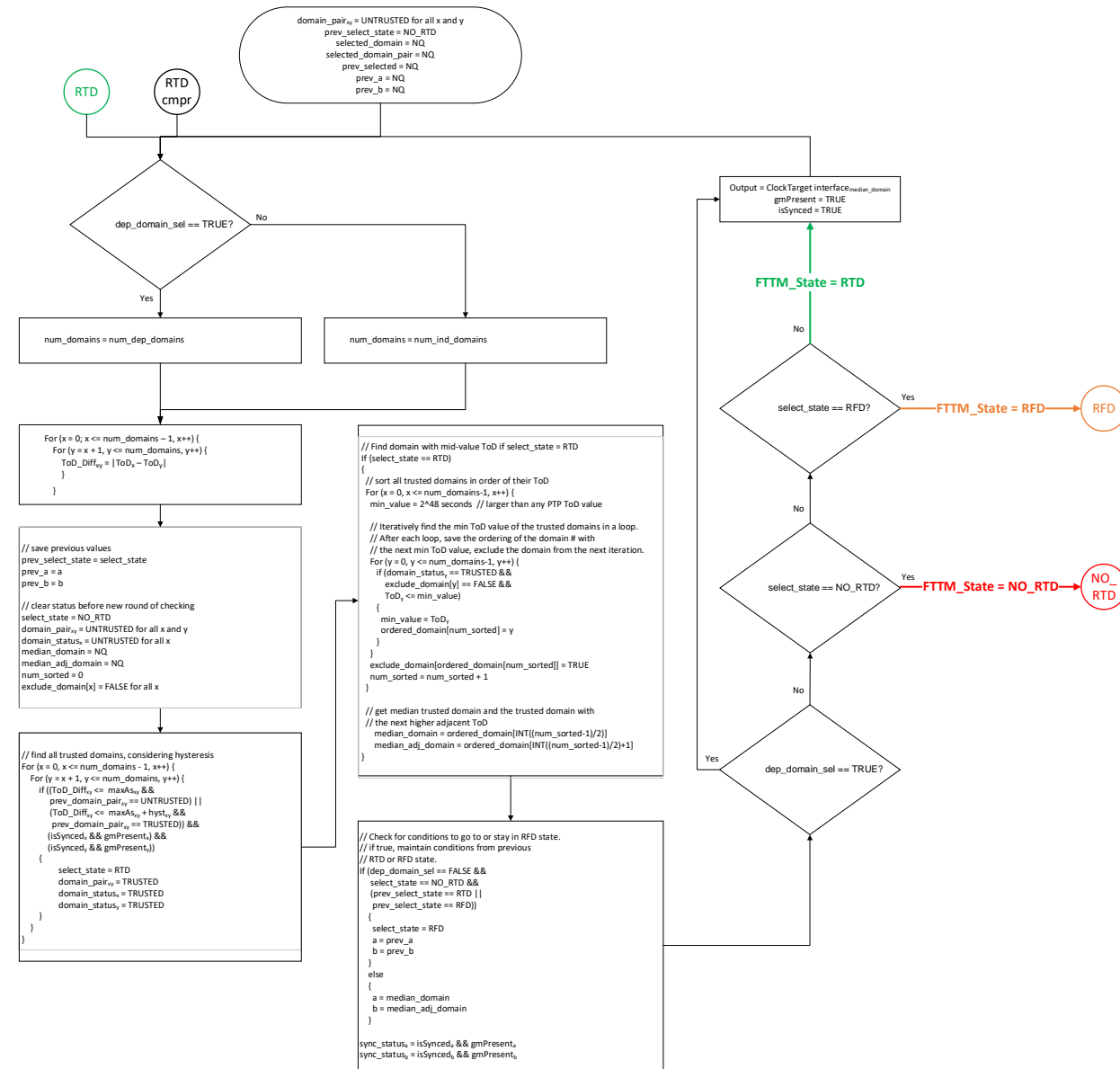
# Closest-pair selection algorithm

- “...compares all possible combinations of domain pairs to determine which pairs have times that match within their specified maxAs threshold” and can be deemed to be trusted
  - gmPresent and isSynced = TRUE is required for domain to participate in selection
  - Hysteresis ( $hyst_{xy}$ ) is included in the threshold used to keep the trusted status
- “...selects the domain that has the highest precedence amongst all the trusted domains”
  - Precedence could be based on  $maxAccumTE_x$ , GM quality, or some other criteria
- May be used by the DDSA and/or the IDSA

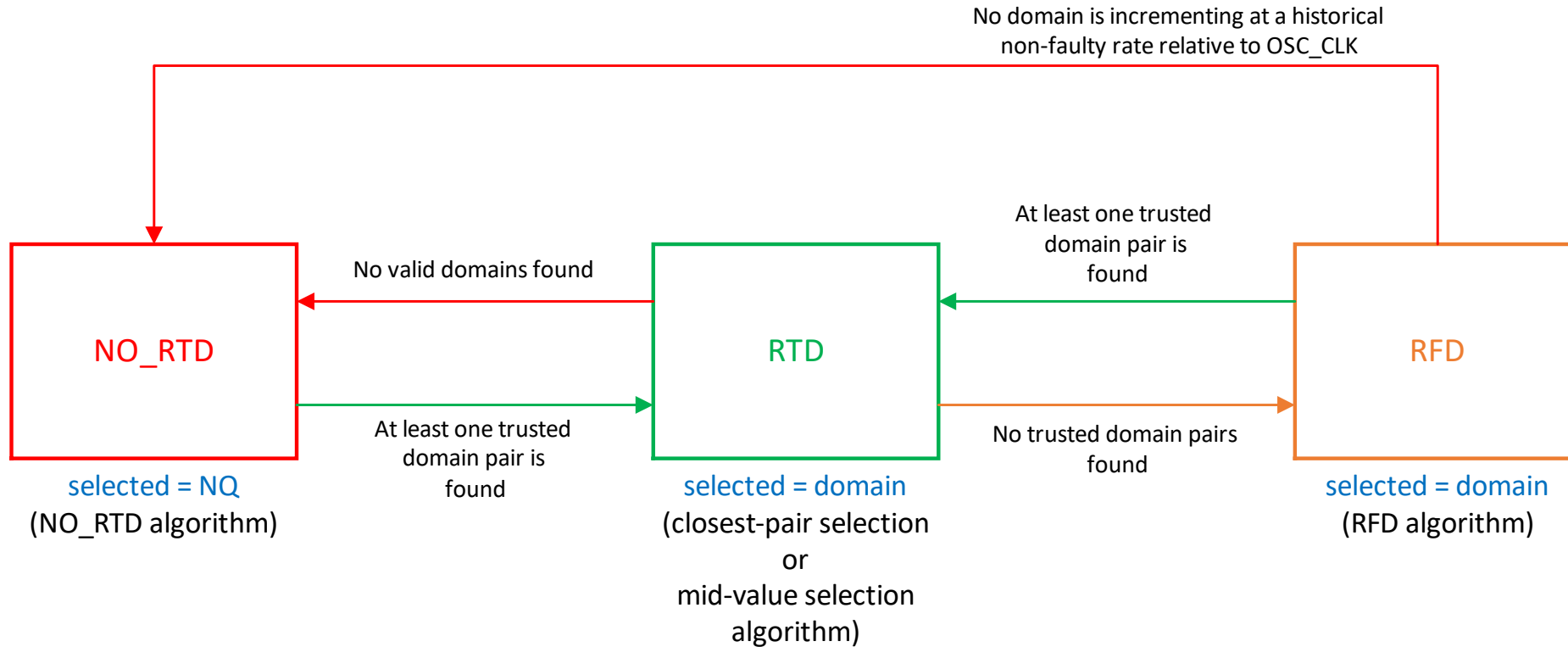


# Mid-value selection algorithm

- “...compares all possible combinations of domain pairs to determine which pairs have times that match within their specified maxAs threshold” and can be deemed to be trusted
  - gmPresent and isSynced = TRUE is required for domain to participate in selection
  - Hysteresis ( $hyst_{xy}$ ) is included in the threshold used to keep the trusted status
- “...selects the domain that has the median time amongst all the trusted domains”
- May be used by the DDSA and/or the IDSA



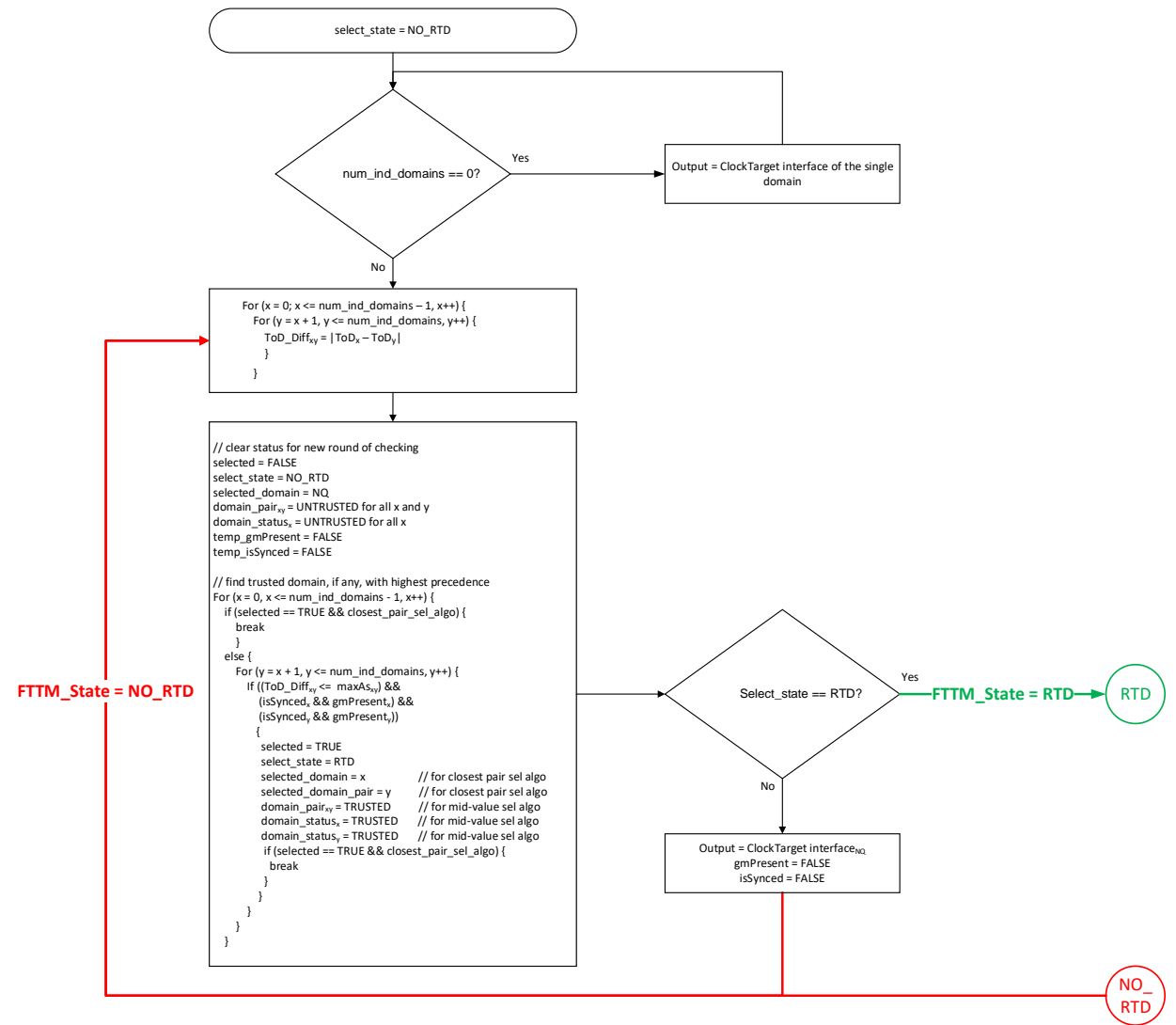
# IDSA state machine



- NO\_RTD: No redundant time domain found
  - Potential availability but not integrity of the time function is achieved
- RTD: Redundant time domain found
  - Availability and integrity of the time function is achieved
- RFD: Redundant frequency used to maintain time domain
  - Availability and partial integrity of the time function is achieved

# Default NO\_RTD algorithm

- “...algorithm compares the skew between all combinations of independent domain pairs, x and y”
- “If any pair of independent domains does not exceed its pre-configured threshold,  $\max AS_{xy}$ , then the two independent domains of the pair are declared to be trusted.”
  - gmPresent and isSynced = TRUE is required for domain to participate in selection
  - Hysteresis ( $\text{hyst}_{xy}$ ) is included in the threshold used to keep the trusted status
- If configured for only one domain, the single domain is presented as the FTTM output

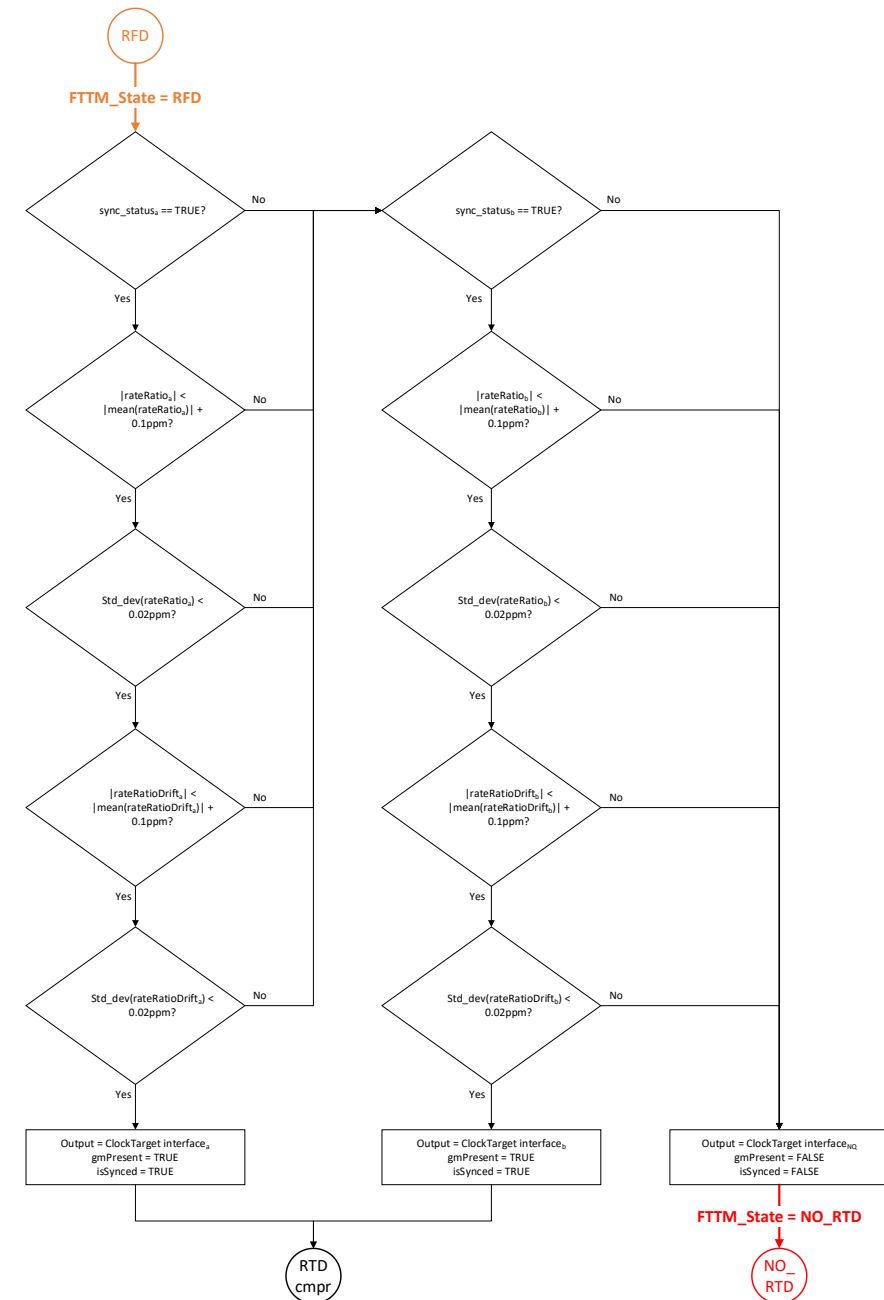


# Default RTD algorithms

- RTD state can use the following default algorithms:
  - closest-pair selection
  - mid-value selection

# Default RFD algorithm

- “...algorithm continuously checks for the presence of trusted domain pairs. If any trusted domain pair is found, then the FTTM moves back to the RTD state.”
- “RFD algorithm checks the current and historical qualities of the last selected domain and its partner (when they were still a trusted domain pair) to determine whether a valid time can still be presented at the FTTM’s output interface.”
  - “If at least one domain from that domain pair is determined, by using the current and historical rateRatio and rateRatioDrift qualities of the domain, to still be within the required thresholds relative to the frequency of OSC\_CLK, then the algorithm remains in the RFD state.”
  - “If no domain from that domain pair remains within the required thresholds, the FTTM moves to the NO\_RT D state”
- rateRatio and rateRatioDrift requirements from IEC/IEEE 60802/D2.1 are used for thresholds





# Future Work for FTTM

# Future work for FTTM

- Balancing integrity vs availability
- Correctness proofs
- What example network topologies with FTTM should be discussed?
  - 2 or 3 point-to-point
    - 2 independent domains + 1 set of dependent domains
    - 3 independent domains
  - Dual-homed
    - 2 independent domains + 1 set of dependent domains
  - Dual-star
    - 2 independent domains + 1 set of dependent domains
  - Bidirectional Ring
    - 2 independent domains + 1 set of dependent domains
  - Mesh
    - 2 independent domains + 1 set of dependent domains
    - 3 independent domains

# Conclusions

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This contribution discussed:

- FTTM functions
  - dependent domains
  - independent domains
- FTTM default algorithms
  - Common parameters
  - NO\_RTD state
  - RTD state and dependent domain selection
    - Closest-pair selection
    - Mid-value selection
  - RFD state
- Future work for FTTM

Questions?