

Caching Real-Time Optimal Strategy Visualization Interval Protocol Development and Performance Analysis with Distributed Tactical Intrusion Detection

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Abstract. Distributed Tactical Intrusion Detection Protocol with the virtual data reduction capability via a caching virtual memory. The basic conceptual software principal is the overlay of the cache virtual memory on the six software algorithms comprising the Real Time Visualization Interval (RTVI) Protocol: (1) Real-Time, (2) Gray Scale and Binary Image Retrieval, (3)Risk Analysis for Edge Detection, (4) Risk Analysis for Image Detection, (5) Minimax Edge Detection for Image Reconstruction, and (6)Clustering. The cache virtual memory is implemented in the Chinese Checker geometric software structure(CCGSS) for the RTVI Protocol as sectors replacing the Chinese Checker marble locations within the six star facets and the center hexagonal structure. Within each of the algorithms, the cache structures are related to the storage required to process these algorithms. It is noted that the cluster algorithm utilizes a hexagonal structure for its placement as sections of the cluster. The six star facets of the CCGSS Protocol can be processed by the cache virtual memory in sequence to execute the surveillance of multiple source attack information realizing the Optimal Strategy Visualization Interval. The Optimal Strategy Visualization Interval is theoretically generated realizing the concept of the Invariant Imbedding of an Optimization theory equation as a kernel in another equation, here, the Games of Timing Optimal Strategy and Optimal Interval equation overlay contains the kernel that is the optimization equation of the six facets equation for the RTVI Protocol.

Keywords: RTVI Protocol, Games of Timing Optimal Strategy, CCGSS Protocol, cache virtual memory, cache structures, Chinese Checker, Real-Time, Risk Analysis, Clustering, geometric software structure, Edge Detection, Gray Scale, Binary Image, hexagonal structure, six star facets, Minimax Edge Detection, Image Detection.

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1. Introduction

Image Visualization, the proliferation of content based image retrieval techniques, has highlighted the need to understand the relationship between image clustering band on low-level image features and image clustering made by users. Image Clustering is an assignment of a set of observations into subsets or clusters so that the observation in the same cluster are cluster pattern recognition hierarchical images,

which are in order of size. Image Reconstruction is the transition of collection of open source algorithms and image problems. The Real-Time Visualization Interval (RTVI) Protocol for Distributed Tactical Intrusion Detection will assist in the real-time detection of conditional attacks such as Ghost-Net[9] and other network security intrusion. The RTVI Protocol will provide intuitive and timely information relative to the overall security posture of the network. Filtering and clustering capabilities will be incorporated to reduce the data set and maintain the essential data set information ensuring that the RTVI Protocol software will operate in the tactical world where bandwidth and processing capabilities are limited and the number of nodes range from a few to thousands. Better visualization will be presented in the RTVI Protocol to present the data generated by the security posture of the network.

In the RTVI Protocol a framework facilitating real-time visual data reduction to alleviate the information overload experienced by the Warfighter. Distributed intrusion detection systems can produce vast amounts of data that can overwhelm the administrators and nodes of a network and can desensitize either because of the constant flood of textual information. In a tactical environment there is enough time to check every entry from network nodes so the RTVI Protocol presents the most important information in an easy manner to understand visual format allowing the user to drill down further into the data. Coordinated stealthy behavior from multiple sensors will be understood with normal visual representation and filtering. Therefore the RTVI Protocol will aid in the detection and notification of network problems, distributed denial of service attacks, reply attitude, data exfiltration, and other malicious behavior coming from coordinated efforts and aid in the attribution of such attacks and that are coming internally, externally or both. The RTVI Protocol will visualize the mathematical concepts of minimax data reconstructions, related risk analysis and overall cache virtual storage implemented within the geometric structure of the Chinese Checker six faceted faces where the segments of the memory in the six star faceted Chinese Checker board are the 121 areas for game pieces.

2. Executive Overview

A real time visualization software protocol for distributed tactical intrusion detection with data reduction to prevent information overload for the Warfighter will be developed and performance analyzed. The unique characteristic of the RTVI Protocol theoretically developed is the Virtual Cache Storage overlaid on the Chinese Checker modeled six sections of the real time visualization distributed tactical intrusion detection software structure. The Game Theory formalism for the Two-Person Sum Game, is used to describe the accessing of the six Algorithms,

$$\Gamma = [S, T, P] \quad (1)$$

where S is the set of Players on the one side of the Chinese Checker Board and T is the Opponent set of Players for the 2,3,4,5, or 6 Chinese Checker Players, which are required to fill the opposite facet to attain the winning strategy P, the Payoff. The concept of the Payoff P is that a Player who is able to transfer all of the playing pieces one by one to the star point directly opposite before anyone is a winner.[17].The Chinese Checker board is the shape of a six pointed star with the center of the board forming a hexagon. Each star point forms a triangle with ten holes. The entire board contains 121 indentations, utilized during the jumping of Players. The Players must be placed into two groupings, because of the layout of the Chinese Checker board to allow the jumps to occur that will fill up the opposite star point. The Two Players begin at the opposite ends of the star, across from each other. The Three Players set up occupying every other points. The Four Players set up with two on one side across

from the other two players. In the Five Players the situation mimics the Six Players game except that one player moves toward the unoccupied corner. The Six Players begin at the opposite ends of the star across from each other. This organization of the Players represents the situation of the Players and Opponents for each number of Players.

The number of combinations of the six star facets(n) taken at the number of Players(r), including both Players and Opponents at a time, is n chose r equals $\frac{(n!)}{(r!(n-r)!)}$. The total player combinations, realizing that there are six total facets for each of the possible Players(including opponents) are: (15 for $r=2$), (20 for $r=3$), (15 for $r=4$), (6 for $r=5$) and (1 for $r=6$). Figure 1 represents the geometric software structure of the RTVI Protocol with the Cache Storage Sectors replacing the marble locations in a six faceted Chinese Checker star. For the basic two image models, binary and grey scale, the following image and edge estimation design assumptions are required to determine the one and two dimensional image reconstruction; regular grid, random shift of the regular grid, random uniform design and jittered regular grid. The smoothness aspect of image reconstruction requires the consideration of boundary fragments for binary and grey scale images. The risk function with R and F algorithm for risk estimation for the error edge estimation requires a Hausdorff Distance and the measure of symmetric difference period. The risk function for image estimation algorithm is also considered. The minimax rate of conversion for edge estimation and image estimation for binary and grey scale images is described in the minimax image reconstruction algorithm.

3. Tactical Real Time Data Reduced Visualization

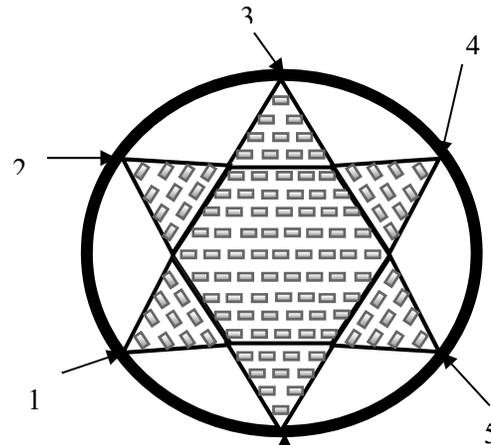
The mathematical formulism for a tactical game with a solution for two strategies and $F(\bar{x})$ and $G(\bar{y})$ is a two person game defined by a triplet (X, Y, Z) where X and Y are two closed sets and ψ , is a real, valued measurable function defined on $X \times Y$; is called the pay-off or a utility function. Then the elements $\bar{x} \in X$ and $\bar{y} \in Y$ element X are pure strategies.[23] The positive measures defined over X and Y are called (mixed) strategies. Therefore, the game has a solution that exists for two strategies, $F(\bar{x})$ and $G(\bar{y})$, such that

$$\int \psi(\bar{x}, \bar{y}) dF(\bar{x}) \geq v, \text{ all } \bar{y} \in Y \quad (2)$$

and

$$\int \psi(\bar{x}, \bar{y}) dG(\bar{y}) \leq v, \text{ all } \bar{x} \in X \quad (3)$$

So F and G are called optimal strategies and v is the value of the game. The class of games that are tactical problems is where each game represents a contest between two players who are trying to obtain the same objectives. When one of these succeeds he/she wins one unit and his/her opponent loses the same amount and the contest is over. The fixed number of attempts by each player must be made during the interval $0 \leq t \leq 1$ where each attempt at $t = 1$ succeeds and each attempt at $t = 0$ fails. At time t_0 the attempt by player I will be successful with probability $P(t)$ and will fail with probability $1-P(t)$. An attempt by player II succeeds with probability $Q(t)$ and fails with $1-Q(t)$. In the formal description of the game x and y will be vectors that describe the time when the attempts are made; The expected gain for Player I is $\psi(\bar{x}, \bar{y})$.



1. Real Time(RT)Algorithm
2. Grey Scale and Binary Image Retrieval(GSBIR) Algor.
3. Risk Analysis for Edge Detection(RAED) Algorithm
4. Risk Analysis for Image Detection(RAID) Algorithm
5. Minimax Edge Detection for Image Reconstruction(MEDIR) Algorithm
6. Cluster(C) Algorithm

Figure 1. RTVI Protocol Cache Virtual Memory Sectors

4. Optimum Caching For Warfighter Data Reduction

4.1 The Caching Concept

The cache concept originally attributed to Belady[2] and D.H. Gibson[13] for the IBM 360/85 computer is to maintain high-speed access to h items from a larger collection of items d items that cannot all be accessed so quickly. A sequence (a_1, a_2, a_3, \dots) is given as integers in the range $0 \leq a_i \leq d$. This sequence represents the items that need to be accessed at time 1, 2, 3...A multiset C_0 of size h is also given; this represents the initial state of the cache. For all integers $t \geq 1$, the cache C_t at time t is defined by,

$$C_t = C_{t-1} - \{b_t\} + \{a_t\} \quad (4)$$

where b is an element of C_{t-1} , in other words C_t is obtained by deleting b_t from C_{t-1} and thus inserting a_t . Hence C_t always has size h and a_t is always in C_t . The particular choice of b_t depends on what caching strategy is being used. If $b_t \neq a_t$ so the cache actually changes at time t we say that a "fault" has occurred. Changes to the cache can be expensive, so the goal of a caching strategy is to minimize the number of faults by judiciously choosing the element b_t that is replaced at time t .

4.2 Replacement Cache Strategy

The assumption that references occur at random, i.e. evenly distributed over the range of all program blocks. Therefore, historical information is irrelevant and any specific replacement rule does not ensure any relative advantage. A random replacement scheme is used to choose the block to be pushed at replacement time at random over the range of all blocks in memory. The efficiency of the random algorithm determines the probability of a wrong decision. Let S be a number of blocks in the problem program. The probability of hitting a particular block at any address reference time is $1/s$. Let c be the number of blocks in memory.[18] Then the probability of referencing a block in memory is c/s and the probability of replacement is $(s-c)/s$. A reference to a block already in memory can be considered repetition, because at least one previous reference must have occurred when the block was pulled. Through the above expressions the ratio of repetition to replacement is $c(s-c)$.

4.3 IBM OS 360/85 Cache

John Liptay [20] described the following parameters for the 360/85 cache. The 360 Model 85 cache was a sixteen K byte integrated storage operating every processor cycle, which can be expanded to 24 K bytes or 32 K bytes. Both the cache and the IBM main storage for the model 85 are logically divided into sectors each continuing of 1 K contiguous bytes starting on 1 K byte boundaries ($K = 1024$). A correspondence is set up between cache sectors and main storage sectors in which each cache sector is assigned to a single different main storage sector. The main storages used on the 360/85 computer are the IBM 2365-5 and the 2385, with a 1.04 micro second cycle time with capabilities of 512 K to 4096 K bytes.

5. RTVI Protocol Algorithms

The basic equation for the RTVI Protocol contains a mathematical representation for each of the six Algorithms: 1. Real Time , 2. Grey Scale and Binary Image Retrieval , 3. Risk Analysis for Edge Detection, 4. Risk Analysis for Image Detection, 5. Minimax Edge Detection for Image Reconstruction, and 6. Cluster, that correspond to the six star facets of the Chinese Checker Game referenced in Figure 1,

$$RTVI = RT + GSBIR + RAED + RAID + MEDIR + C \quad (5)$$

The unusual characteristic of the RTVI Protocol modeling on the Chinese Checker Game allows the combination of the six RTVI Protocol Algorithms according to the Chinese Checker Game Players and Opponent Players attaining of the six Star Facets. The optimized RTVI Protocol is represented by $RTVI_{OPT}$ with Lagrang Multiplier α for the Perceived Threat(PT) Constraint and Lagrange Multiplier β for the Visualization Threat(VT) Constraint,

$$RTVI_{OPT} = RTVI + \alpha[PT - PT_c] + \beta[VT - VT_c] \quad (6)$$

is Invariant Imbedded[10] as the kernel $K(x,y)$ into the Games of Timing equation[24], to obtain the Optimal Strategy Visualization Interval.

$$\int_0^1 \int_0^1 K(x,y) dF(x) dG(y), \quad K(x,y) = -K(y,x) \quad (7)$$

6. Real Time Algorithm

The creation of a timing chart for algorithm processing and regulation of simulation analysis is included with the six topological network models, (1) Hierarchical Tree, (2) Centrally Connected, (3) Shockwave Rider-Type, (4) Hierarchical Tree Several Layers of Authority and Many Centralized Nodes,[11].

7. Grey Scale and Binary Image Retrieval Algorithm

Image analysis requires reconstruction of pictures from noisy data or estimation.[18] The two special features related to this problem are: (1) The data arrays are two dimensional, (2) The image f is composed of several regions with sharp edges. In each type equation here in each region the image preserves a degree of uniformity, while on the boundaries between the regions. It has considerable changes. It is important to find the boundary's edge of such regions. This results in edge estimation or edge detection. Edge detection requires smoothing by a kernel controlled on a small interval and with positive and negative values. These kernels mimic differentiation. The line's characteristic of differentiation operators yields methods that do not achieve the optimal rates of convergence if the edge is really a discontinuity. Comparison of different image and edge estimators on the common scale. In order to reconstruct images there is a comparison of different images and edge estimation on a common scale. Minimax approaches are suited well for comparison of estimators in nonparametric regression and change point problems. The statistical model of noisy images requires considering the following sample of observations.

$$Y_i = f(x_i) + \xi_i, \quad i=1, \dots, n \quad (8)$$

f = unknown function of the 2 dim. argument = image

X_i 's belong to the unit square $K = [0,1] \times [0,1]$

ξ_i = random variables

x_i = design points are fixed or random

ξ_i are iid

(ξ_1, \dots, ξ_n) are independent of the design points

$$X^{(n)} = ([X_1, Y_1], \dots, [X_n, Y_n]) \quad (9)$$

The image is associated with a domain G inside K . K is divided into two parts: The domain G where the values of f are large and the background $G = K/G$ where the values are small. Assume f has a jump discontinuity at the boundary $\Gamma = \partial G$ of the domain G . The curve Γ is called edge.

The following two image models are considered:

7.1 Binary Image

$$f(x) = I(x \in G) = \begin{cases} 1 & \text{if } x \in G \\ 0 & \text{if } x \in \bar{G} \end{cases} \quad (10)$$

Reconstruction of binary images reduces to estimation of domain G from observations or equivalently to estimation of the edge Γ .

7.2 Grey-Scale Image

The values of f_0 and f_1 be separated in a certain way.[18] For example, it is sufficient to assume that

$$f_0(x) \leq a < b \leq f_1(x) \quad (11)$$

with some known or unknown constants a and b . The estimation of grey scale images f is from observations and edge estimation is the estimation of G and Γ for binary and grey scale images. 1. Assumptions on the design of edge estimation and image estimation are,

7.2.1 Regular grid. Let $n_1 = n^{1/2}$ be an integer. Define $X_i = (k/n_1, e/n_1)$ where $i = (k-1)n_1 + e$, $k, e = 1, \dots, n_1$. The set (X_1, \dots, X_n) is called regular grid.

7.2.2 Random shift of the regular grid. Occasionally it is assumed that an image or a part thereof is blurred. This is expressed by the following definition: $X_i = (k/n_1 - \eta_1, e/n_1 - \eta_2)$ where $i = (k-1)n_1 + e$, $k, e = 1, \dots, n_1$, and n_1, n_2 are independent random variables uniformly distributed in $[0, 1/n_1]$. These designs impose strong restrictions on the convergence rates of image and estimators. If the edge is smooth enough then the minimax convergence rates cannot be achieved with regular design. Therefore other designs are used under which the minimax rates are possible.

7.2.3 Random uniform design. The design points X_i are independent random points uniformly distributed in K .

7.2.4 Jittered regular grid. Let $n_1 = n^{1/2}$ be an integer.

$$X_i = \eta_{ke} \text{ for } i = (k-1)n_1 + e \quad (12)$$

where η_{ke} are independent random points uniformly distributed in the small squares $[(k-1)/n_1, k/n_1] \times [(e-1)/n_1, e/n_1]$, $k, e = 1, \dots, n_1$.

8. Risk Function For Edge Estimation

\widehat{G}_n is an estimator of the domain G . \widehat{G}_n is a closed subset of K measurable with respect to observations (X_i, Y_i) . [18] The measure of the error of edge estimation is a distance $d(G, \widehat{G}_n)$. In considering distance both the Hausdorff definition and the measure of symmetric difference are used. The Hausdorff distance definition is as follows,

$$d_\infty(G_1, G_2) = \max\{\max_{x \in G_1} \rho(x, G_2), \max_{x \in G_2} \rho(x, G_1)\} \quad (13)$$

where $\rho(x,G)$ is the Euclidean distance between a point x and a closed set G . For $G_1, G_2 \in \zeta_0$ the Hausdorff distance is equivalent to the L_∞ -distance between the corresponding functions $g_1(x_1)$ and $g_2(x_1)$. Boundary fragments are accounted for by the following equation:

$$d_\infty(G_1, G_2) = \sup_{0 \leq x_1 \leq 1} |g_1(x_1) - g_2(x_1)| \quad (14)$$

The measure of symmetric difference is as follows: Let $G_1 \Delta G_2$ be the symmetric difference between compact sets G_1 and G_2 . Define the distance as the Lebesgue measure of $G_1 \Delta G_2$.

$$d_1(G_1, G_2) = \text{mes}(G_1, \Delta G_2) \quad (15)$$

For $G_1, G_2 \in \zeta_0$ this equals the L_1 -distance between the corresponding functions $g_1(x_1)$ and $g_2(x_1)$:

$$d_1(G_1, G_2) = \int_0^1 |g_1(x_1) - g_2(x_1)| dx_1 \quad (16)$$

For binary images $f(x) = I \{x \in G\}$ denote by P_G the probability measure generated by observations (X_i, Y_i) , $i = 1, \dots, n$, where G is the image domain. Denote by E_G the expectation with respect to P_G . The risk function for edge estimation is defined here as

$$R(\hat{G}_n, G) = E_G (w(\psi_n^{-1} d(G, \hat{G}_n))) \quad (17)$$

where the distances are $d = d_1$, $d = d_\infty$ and the loss functions are $w(u) = u^2$ (squared loss), $w(u) = |u|$ (absolute value loss), $w(u) = I\{|u| \geq C\}$, $C > 0$ (indicator loss); ψ_n is a positive normalizing sequence.

8.1. Risk Function For Image Estimation

Let $T_N(x)$ be an image estimator (a function on K measurable with respect to observations). The error of T_N is determined[18] in a standard way by means of a nonnegative risk function $R(T_N, f)$. We use the L_2 -risk with squared loss function as defined below

$$R(T_n, f) = \psi_n^{-2} \text{MISE}(T_n, f) = \psi_n^{-2} E_f \left(\int (f(x) - T_n(x))^2 dx \right) \quad (18)$$

Here T_n is an arbitrary estimate of f and E_f is the expectation with respect to the distribution of and observations (X_i, Y_i) , $i = 1, \dots, n$.

9. Minimax Rate Of Convergence For Edge Estimation

In this problem the estimate parameter is the set G , and the pseudometrics are $d = d_1$ and $d = d_\infty$. [18] Hence, the positive sequence $\psi_n = I$ -minimax rate of convergence for edge estimation occurs if there exist two positive numbers $p_0 < 1$ and C . Here d is a distance between compact sets, e.g. the Hausdorff distance or the measure of symmetric difference. The estimator G_n^* is called I -optimal edge estimator. ψ_n is the S-minimax rate of convergence for edge estimation if for any n large enough with some positive C_0, C_1 , and

G_n^* is the optimal estimator if for all n. For the case of boundary fragment definitions are analogous (replace G by G_0 everywhere).

10. Cluster Algorithm

The nine, three, three and five hexagonal structure groupings will be utilized as cluster sections contouring the RTVI Protocol, which has a hexagonal base structure. In this manner execution of the six algorithms of the RTVI Protocol with caching can achieve grouped processing as previous forms of cluster algorithms.

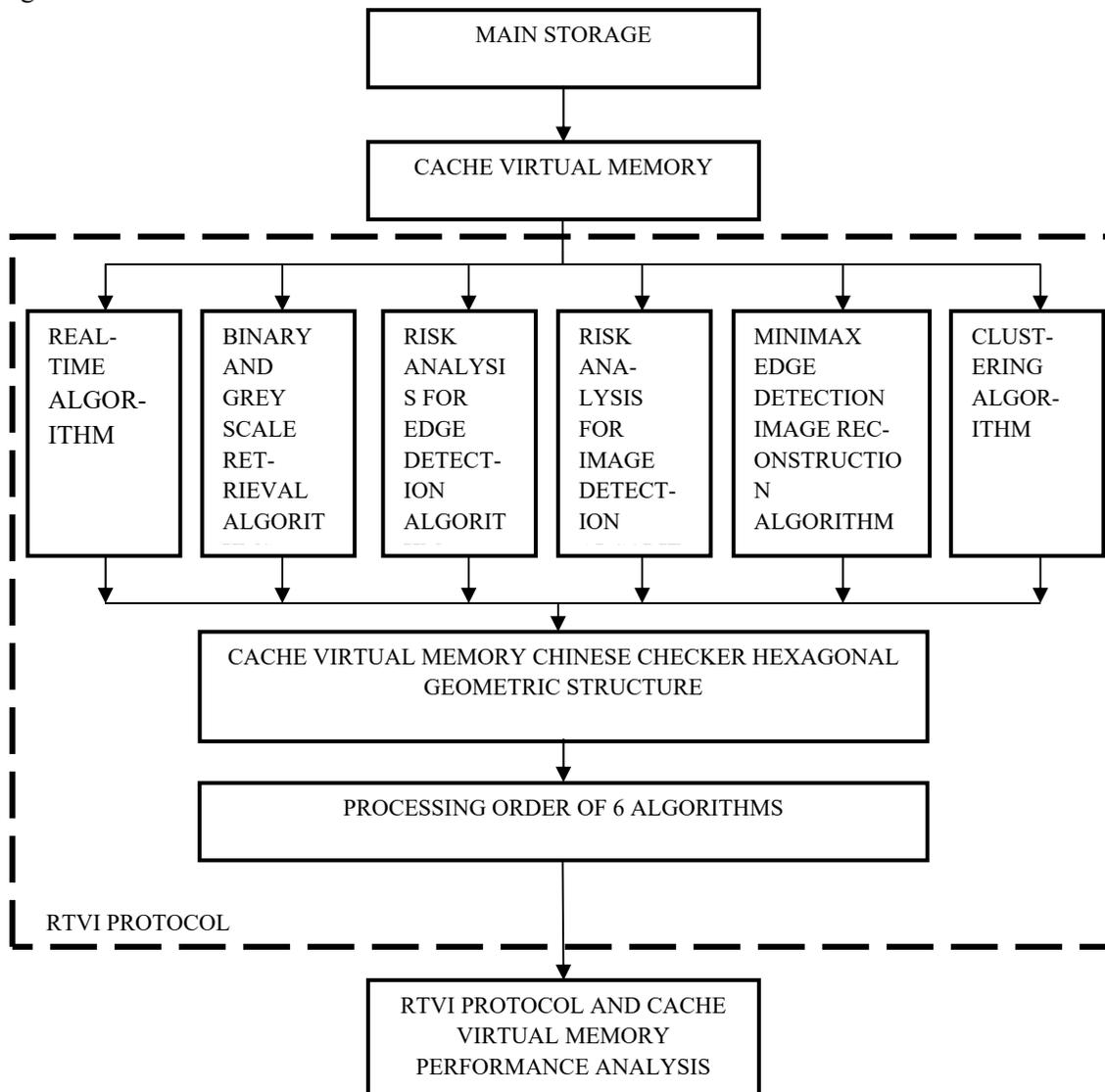


Figure 2. RTVI Protocol and Cache Virtual Memory Flow Chart

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