





$$ipd'_{i,j} = t'_j - t'_i \tag{8}$$

We will define the impact on  $ipd'_{i,j}$  by attacker .so the impact will be,

$$ipd_{i,j} - ipd'_{i,j} = d_j - d_i \tag{9}$$

Here we will use the  $i$ th and  $j$ th packets timestamps to calculate incoming and outgoing inter-packet delay in the packet flow.

Here the negative impact of using invalid packet due to packet reordering will be equivalent to random timing impact over inter-packet delay. Let  $D$  be the maximum delay that attacker can add to  $p_i$  ( $i = 1, \dots, n$ ), for  $D > 0$ .

Hence the impact will be  $d_j - d_i$  belongs to  $[-D, D]$ . Where  $[-D, D]$  is called as impact range of attacker. To make the correlation more robust, we embed watermark using IPDs from randomly and independent selected packets. For the packet sequence  $p_1, \dots, p_n$  along with the timestamp  $t_1, \dots, t_n$  respectively ( $t_i < t_j$  for  $1 \leq i < j \leq n$ ), we probabilistically choose  $2m < n$  packets by following process: Firstly we consider each of  $n$  packets sequentially and secondly independently determining if current packet will be chosen with the probability  $p = 2m/n$  ( $0 < m < n/2$ ) for watermarking purpose .Here for the purpose of watermarking ,selection of one packets is independent from the selection of another packet. So,  $2m$  will be distinct packets selected randomly from  $n$  packets.

### 3.3 Detecting Watermark Existence

Let the secrete information shared between the watermark embedder and decoder be represented as  $\langle S, m, l, s, w \rangle$  where  $S$  is the packet selection function that returns  $(l+1) \times m$  packets  $\geq 1$  is the number of redundant pairs of packets in which to embed one watermark bit,  $l > 0$  is the length of the watermark in bits,  $s > 0$  is the quantization step size, and  $w$  is  $l$ -bit watermark to be detected,. Let  $f$  denotes the flow to be examined and  $wf$  be the decoded  $l$  bits from flow  $f$ .

The watermark detector works as follows:

First Decode the  $l$ -bit  $wf$  from flow  $f$  and then compare the decoded  $wf$  with  $w$ . After both this steps report the watermark  $w$  is detected in flow  $f$  if the hamming distance between  $wf$  and  $w$  ,represented as  $H(wf, w)$  is less than or equal to  $h$  ,where  $h$  is a threshold parameter determined by the user and  $0 \leq h < 1$ . Let  $0 < p < 1$  be the probability that each embedded watermark bit will survive the timing perturbation by attacker. Then probability that all  $l$  bits survive the timing perturbation by the attacker will be  $p^l$  will tend to be small unless  $p$  is very close to 1.

By using hamming distance  $h$  to detect the watermark  $wf$ , the expected watermark detection rate will be,

$$\sum_{i=0}^h \binom{l}{i} p^{l-i} (1-p)^i \tag{10}$$

For  $i=0$  to upper the upper bound  $h$ .

For example, for the value  $p=0.9102$ ,  $l=24$ ,  $h=5$ , the expected watermark detection rate with exact bit match would be  $p^l = 10.45\%$ . For the same values of  $p$ ,  $l$ ,  $h$ , the expected watermark detection rate using a hamming distance  $h=5$  would be  $93.29\%$ .

## 4. Experiment and Analysis

### 4.1 Watermark bit embedding and decoding

Generally, watermarking involves the selection of a watermark carrier, and the design of two complementary processes: embedding and decoding. In the registration, we collect the watermark signature... The watermark embedding process inserts the information by a slight modification of some property of the carrier. The watermark decoding process detects and extracts the watermark (equivalently, determines the existence of a given watermark). To correlate encrypted connections, we propose to use the inter-packet timing as the watermark carrier property of interest. The embedded watermark bit is guaranteed to be not corrupted by the timing perturbation. If the perturbation is outside this range, the embedded watermark bit may be altered by the attacker. The watermark embedding and decoding process will be as follow:

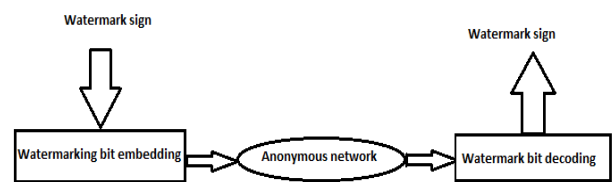


Figure 1: Watermark bit embedding and decoding

As an IPD is conceptually a continuous value, we will first quantize the IPD before embedding the watermark bit. Given any  $IPD \ ipd > 0$ , we define the *quantization of ipd* with uniform quantization step size  $s > 0$  as the function

$$q(ipd, s) = round(ipd/s) \tag{11}$$

where  $round(x)$  is the function that rounds off real number  $x$  to its nearest integer  $ipd$ .

It is easy to see that  $q(k \times s; s) = q(k \times s + y; s)$  for any integer  $k$  and any  $y \in [-s/2; s/2]$ . Let  $ipd$  denote the original IPD before watermark bit  $w$  is embedded, and  $ipd_w$  denote the IPD after watermark bit  $w$  is embedded. To embed a binary digit or bit  $w$  into an IPD, we slightly adjust that IPD such that the quantization of the adjusted IPD will have  $w$  as the remainder when the modulus 2 is taken. Given any  $ipd > 0$ ,  $s > 0$  and binary digit  $w$ , the watermark bit embedding is defined as function.

$$e(ipd, w, s) = [q(ipd + s/2, s) + \Delta] \times s \tag{12}$$

Where,  $\Delta = (w - (q(ipd + s/2, s) \bmod 2) + 2) \bmod 2$ .

The embedding of one watermark bit  $w$  into scalar  $ipd$  is done through increasing the quantization of  $ipd+s/2$  by the normalized difference between  $w$  and modulo 2 of the

quantization of  $ipd+s/2$ , so that the quantization of resulting  $ipd^w$  will have  $w$  as the remainder when modulus 2 is taken. The reason to quantize  $ipd+s/2$  rather than  $ipd$  here is to make sure that the resulting  $e(ipd,w,s)$  is no less than  $ipd$ , i.e., packets can be delayed, but cannot be output earlier than they arrive. The watermark bit decoding function is defined as

$$d(ipd^w, s) = q(ipd^w, s) \text{ mod } 2 \tag{13}$$

Algorithm for watermark bit detection will be as follow:

Watermark detection refers to the process of determining if a given watermark is embedded into the IPDs of a specific connection or flow. Let the secret information shared between the watermark embedder and decoder be represented as  $\langle S, m, l, s, w \rangle$ , where  $S$  is the packet selection function that returns  $(l+1) \cdot m$  packets,  $m \geq 1$  is the number of redundant pairs of packets in which to embed one watermark bit,  $l > 0$  is the length of the watermark in bits,  $s > 0$  is the quantization step size, and  $w$  is the  $l$ -bit watermark to be detected. Let  $f$  denote the flow to be examined, and  $wf$  denote the decoded  $l$  bits from flow. The watermark detector works as follows:

1. Decode the  $l$ -bit  $wf$  from flow  $f$ .
2. Compare the decoded  $wf$  with  $w$ .
3. Report that watermark  $w$  is detected in flow  $f$  if the Hamming distance between  $wf$  and  $w$ , represented as  $H(wf, w)$  is less than or equal to  $h$ , where  $h$  is a threshold parameter determined by the user, and  $0 \leq h < l$ .

#### 4.2 Mathematical Model

Once user submit request, it contains watermark image embedded with the file and that file is send in the format of packets in the form of intervals .And admin detects the authenticate user by using detection algorithm.

#### Intersect and Merge Approach

The Figure shows mathematical model for mapping input real user requests with encrypted file embedded with watermark image.

Assume the set  $(U_1, U_2, U_3, \dots, U_n)$  is the set of requested users and  $(w_1, w_2, \dots, w_3, \dots, w_n)$  are the watermark image for the respective users .

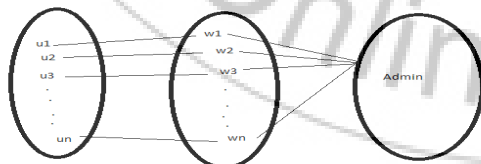


Figure 2: Mathematical Model

#### 4.3 Experimental Components

##### Detection Algorithm

**Detection:** The probability of detecting real edge points should be maximized while the probability of falsely

detecting non-edge points should be minimized. This corresponds to maximizing the signal-to-noise ratio.

Let  $\pm i$  be the delay added to packet  $P_i$ , and  $t_0 i$  be the distorted time stamp of packet  $P_i$ , then  $t_0 i = t_i + \pm i$ . The original and distorted inter-packet delays (IPD) between  $P_{i+1}$  and  $P_i$  are  $I_i = t_{i+1} - t_i$  and  $I_0 i = t_0 i+1 - t_0 i$  respectively. Therefore,  $\pm k = t_0 k - t_k = \pm 1 + kX; I_i = 1(I_0 i - I_i)$ . The original and the perturbed inter-packet timing characteristics of packet flow  $P_1; \dots; P_n$  can be represented by  $\langle t_1; I_1; \dots; I_{n-1} \rangle$  and  $\langle t_0 1; I_0 1; \dots; I_0 n-1 \rangle$  respectively. In, particular,  $\langle I_0 1; I_0 n-1 \rangle$  represents the distortion pattern over the original inter-packet timing characteristics.

According to results from section VI-A, in order to completely remove any hidden information from the original interpacket timing characteristics, the adversary needs to disturb  $\langle t_1; I_1; I_{n-1} \rangle$  into an independent one. That means  $\langle I_0 1; \dots; I_0 n-1 \rangle$  needs to be independent from  $\langle I_1; \dots; I_{n-1} \rangle$ .

Therefore, the distortion pattern  $\langle I_0 1; \dots; I_0 n-1 \rangle$  can be thought to be pre-determined before the original inter-packet timing characteristics .

#### 1) Watermarking Engine:

**Watermark generator:** The watermark generator generates unique watermarks with a specified hamming distance. The distance is important to ensure low false positives. These watermarks are embedded into traffic flows by the watermarking engine. The delay introduced by the watermark has to be small in order to make it difficult for the attacker to determine if his flow is watermarked. All the watermarks are 24 bits in size. The watermarks are generated such that the minimum hamming distance between any two watermarks is 5. A watermarking delay of 3ms was sufficient to confuse the attacker and achieve high true positive rate.

#### 2) Watermark decoder

The watermark decoder acts as the egress monitor which checks outgoing traffic flows for watermarks. It is assumed that there is coordination between the watermarking engine and the decoder knows which packets are watermarked. The watermark that is found is decoder compared with all the embedded watermarks and analyzed to determine false positives. For a detection scheme to be effective, it should not only have a high detection rate but also a low *false positive* rate. A *false positive* can occur when the watermark decoder erroneously finds a watermark in an un-watermarked flow or in a flow that has a different watermark.

In this project, we address the random timing perturbation problem in correlating encrypted connections through stepping stones. Our goal is to develop an efficient correlation scheme that is probabilistically robust against random timing perturbation, and to answer fundamental questions concerning the effectiveness of such techniques and the tradeoffs involved in implementing them. We propose a novel watermark-based correlation scheme that is

designed specifically to be robust against timing perturbations by the adversary. Unlike most previous correlation approaches, our watermark-based approach is *active*; that is, it embeds a unique watermark into the encrypted flows by slightly adjusting the timing of selected packets.

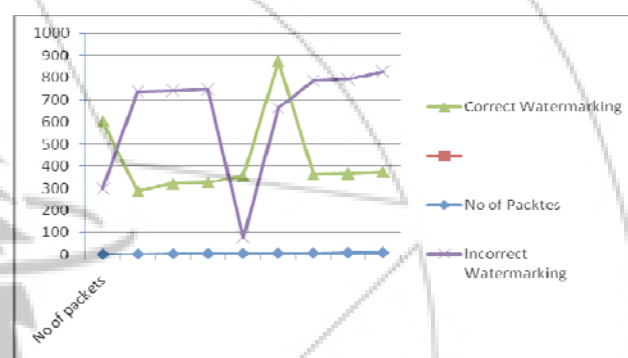
Previous timing based correlation method that considers both correlation true positive and false positive at the same time. Based on the assumption that the inter-packet timing of flows can be modeled as a sequence of Poisson processes of different rates, they derived upper bounds on the number of packets needed to achieve a specified false positive rate and a true positive rate. However, their work did not present any experimental results, nor did it address such practical issues as how to derive model parameters in real-time or how many packets are needed in practice for real flows and realistic timing perturbations. Passive approaches are simple to implement and undetectable by the attacker. However, they generally make more limiting assumptions about the inter-packet timing characteristics, and require more packets than an active approach to effectively correlate timing perturbed flows, as we will show. We have also compared the effectiveness and the numbers of packets needed by our active watermark correlation approach, and a representative passive correlation approach, under identical levels of timing perturbation on the same sets of traces. For Poisson arrivals, aimed that its detection algorithm DETECT-ATTACKS guaranteed to achieve a detection rate and false positive rate given sufficient number of packets. However, it did not include any experimental results that demonstrated the claimed effectiveness. To empirically compare the effectiveness of our active approach and that of the passive correlation method of we implemented detection algorithm, and after identifying the maximum number of packets in any time interval from flow we applied detection algorithm, with to correlate flows and the corresponding perturbed flows with maximum uniformly distributed perturbation. Surprisingly, the detection algorithm DETECT-ATTACKS in this test only achieved a 79.5% detection rate, while experiencing no false positives. Our watermark-based correlation method achieved at least a 91.9% true positive rate and about a 0.3% false positive rate, using parameter values of  $h=5$ ,  $l=24$ ,  $s=400$ ms and  $m=12$  on flow. Our active watermark-based correlation makes no assumptions about the original distribution of the inter-packet timing of the original packet flow, and it does not require the adversary's timing perturbation to follow any specific distribution or random process to be effective. Our active watermark-based correlation was shown to require substantially fewer packets than a representative passive timing-based correlation method to achieve a given level of robustness.

Following shows the table with its correct watermarking.

**Table 1:** Correct Watermarking signature

No of Packets	Correct Watermarking	Incorrect Watermarking
1	604.395	298
2	288	738
3	322	743
4	327	749
5	358	78
6	873	664
7	364	787
8	369	794
9	377	830

Following shows the figure with its correct watermarking and incorrect watermarking plotting.



**Figure 3:** no of packets with its IPT in ms

## 5. Conclusion

The random timing perturbation greatly reduces the effectiveness of passive timing approaches. In this paper, we analyze the active watermarking scheme for tracing through stepping stones. Our active watermark-based correlation requires fewer packets than a passive timing based correlation method to achieve a given level of robustness. Here we identified the provable upper bounds on the number of packets needed to achieve desire correlation effectiveness under given level of perturbation. One interesting area of future work is to investigate how to make the flow watermarking more robust with fewer packets.

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