

# Experience With Software Watermarking

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“Embedding Watermarking in dynamic data structures ... can be done efficiently with moderate increases in code size, execution times, and heap-space usage”

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## Article Outline and My Focus

- Introducing software watermarking and attacks
- Embedding watermark in dynamic data structures
  - Representing watermark as a PPCT tree
  - Embedding watermark in Java program (**My Focus**)
  - Theoretical retrieval of the watermark
- Result analysis (**My Focus**)
- Integration with other techniques

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# What Do We Need To Know

- Theory of Embedding watermark in dynamic data structures
  - refer to “Software watermarking: Models and dynamic embeddings” by Christian Collberg and Clark Thomborsen
- How to represent a watermark?
  - Assume watermark is a number
  - Use PPCT tree (Planted Plane Cubic Tree) to represent this number

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# Embedding WM with JavaWiz

- What we need to do?
  - Choose a number (to represent watermark)
  - Choose a base class (to be the node of PPCT tree in the future)
  - Choose where to insert code for construct PPCT
- What can be done by JavaWiz?
  - Covert number to PPCT representation
  - Convert base class into a **node class**
  - Insert offline code for construct PPCT

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# Convert base class into a node class

- By Insert some fields and pointers into the class
- Example:

```
class Hello{
    public static void main(String[] args){
        A a=new A();
        a.print();
    }
}
Class A{
    public A(){ }
    public void print( ) { System.out.println("Hello!"); }
}
```

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# Convert to node class Cont.

- Insert code into class A()

```
Class A{ // Insert fields and pointers below
```

```
static A[] nd=new A[300];
int nd_counter=0;
A leftLeave, rightLeave;
static public void setEdge(int i1, int i2, int i3) {
    if (nd[i1]==null) nd[i1]=new A();
    if (nd[i2]==null) nd[i2]=new A();
    if (nd[i3]==null) nd[i3]=new A();
    nd[i1].leftLeave=nd[i2];
    nd[i1].rightLeave=nd[i3];
}
```

```
public A(){ }
public void print() {...}
}
```

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# Insert code for construct PPCT

- Insert code into method main()

```
class Hello{  
    public static void main(String[] args){  
  
        A.setEdge(0,299,1);  
        A a=new A();  
        A.setEdge(1,2,3);  
        A.setEdge(2,0,2);  
        a.print();  
        A.setEdge(3,4,5);  
        .....  
    }  
}
```

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# Result Analysis

- Add 4-12 kb code for WM
- Embedding can be done in 4-20 seconds
- Execution time increases 2-7%
- Heap-space increase depends on node class object
- Retrieval done in about 1minute/Mb of heap

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## Conclusion

- Embedding watermark in dynamic data structures is an efficient way against attack
- Watermark represented as PPCT
- Choose a base class, convert it into a node class
- Add code to construct PPCT at run time
- Hard to retrieve without clue
- Reasonable performance
- May combine other protection methods for better result

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## Discussion

- Is PPCT tree isolated from other structures? Can it be easily located by attacker ?
- PPCT tree has a lot of nodes in memory, if any of the node is found, the root will be retrieved, do you think it is a big risk?
- Do you think the authors find a good way for embedding WM in dynamic data structures?

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