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A Pattern-based Methodology for Modeling Investigations in CFTaaS Architectures

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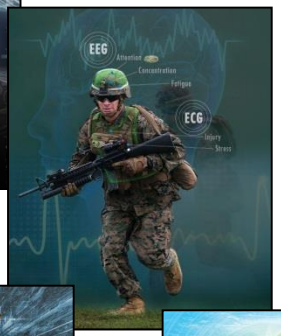
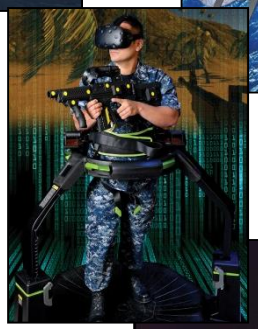
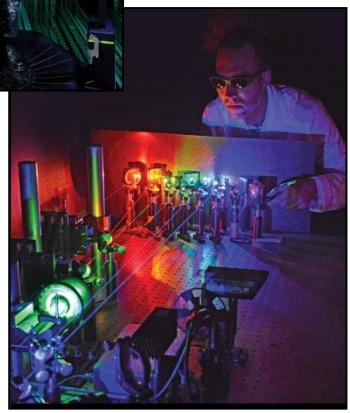
From concept to capability via…







…research, development, engineering, and support of integrated C4ISR, cyber, and space systems across all warfighting domains

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Cyber Forensics Research Lab (CFRL)

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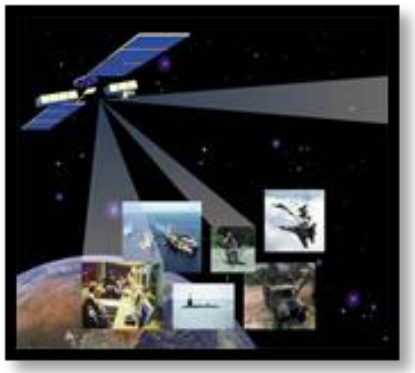
Mission

- Investigate novel ways to collect, protect, analyze network-based evidence.
- Understand collection, classification/exploitation of knowledge about adversaries (cyber threat intelligence) from a cyber-forensics perspective.
- Perform network forensics investigations in different DoD environments (e.g. cloud-based, mobile, converged, tactical), analyze traffic and flow records, behavior analysis, and generate intelligence.
- Platform for investigating network attacks and training our engineers and scientists
- Research collaboration with industry, academia and government.

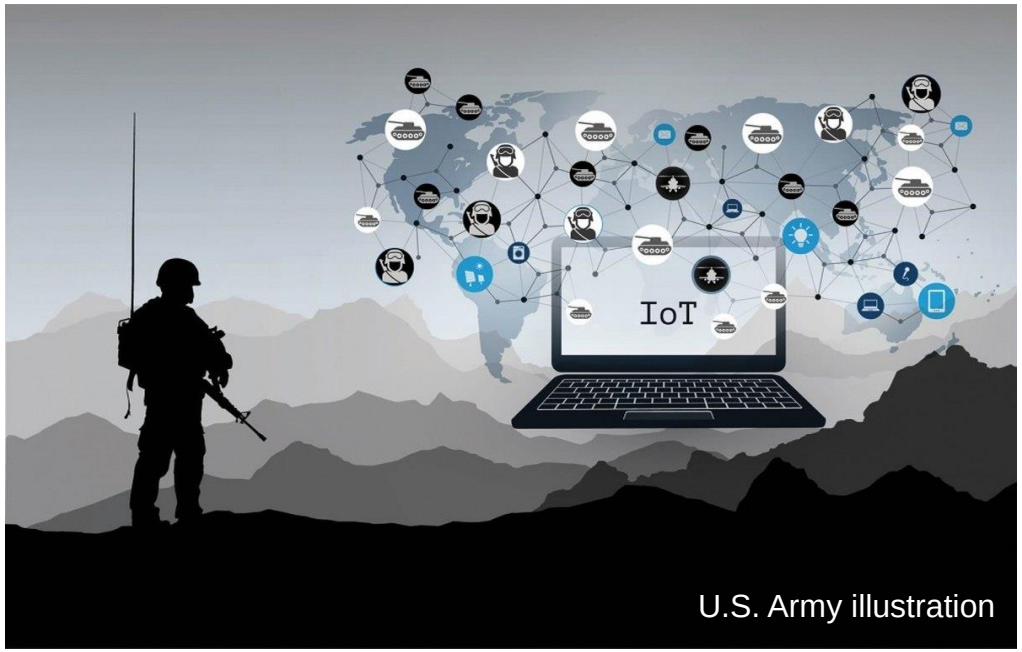


Operational Relevance

- Enables DCO forces to detect incidents across multiple Navy networks
- Allows DCO forces to conduct network monitoring and analysis within a converged environment
- Develop novel forensic tools and methods to conduct live cyber forensic investigations
- Support network investigators to identify actual intrusions, collect more and better evidence, reduce analysis time, and help to stop attacks against the converged network.
- Improving cyber posture for immediate and persistent cyber threats to networks
- Reduction in threat detection to response time
- Reduction in Cyber Analyst Information Overload

Internet of Battlefield Things (IoBT)

- Growth of smart infra-structure, cloud and IoT devices added more attack surfaces.
- It's expensive to build cyber forensics testbeds and gain expertise in the field
- Need for a federated testbed to integrate isolated testbeds.
- Emerging UC/5G technologies as key future communication platforms



U.S. Army illustration

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Secure Systems Development Methodology

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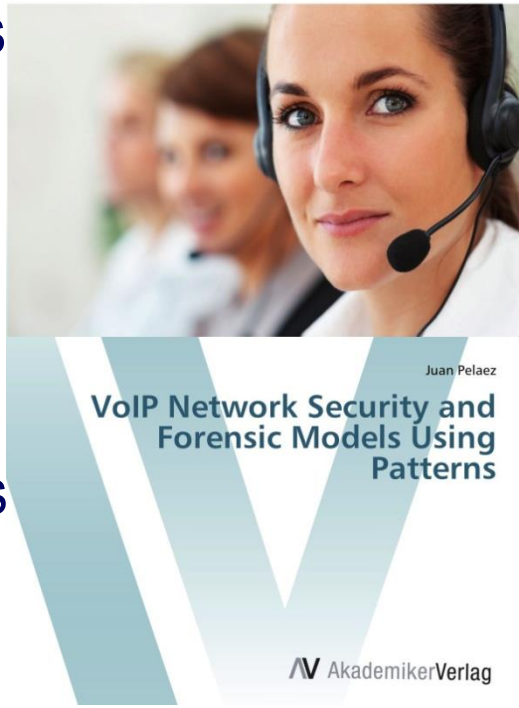
- OO models can be converted into software.
- Dynamic aspects of model can be implemented as ops classes and the data parts of a class can be mapped to relational databases.
- UML accepted standard for s/w development. UML visual language appropriate for description of system architecture.
- Software patterns are established for software analysis design to improve reusability and reliability.
- Approach combines UML and patterns to present models and mechanisms for security and forensics.
- Patterns used to build or evaluate secure systems or for teaching security (UDEL ELEG/CPEG 467-667, Introduction to Network Security)



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Network Models Using Patterns

- Discover new ways to characterize network environments and information embedded in the network.
- Comprehensive pattern system based on a collection of semi-formal patterns.
- Analyze network forensic investigations in converged environments using forensic patterns.
- Pattern systems specify, analyze and implement network forensics investigations for different architectures.
- Secure and convenient method of collecting/analyzing digital attack evidence in converged environments.

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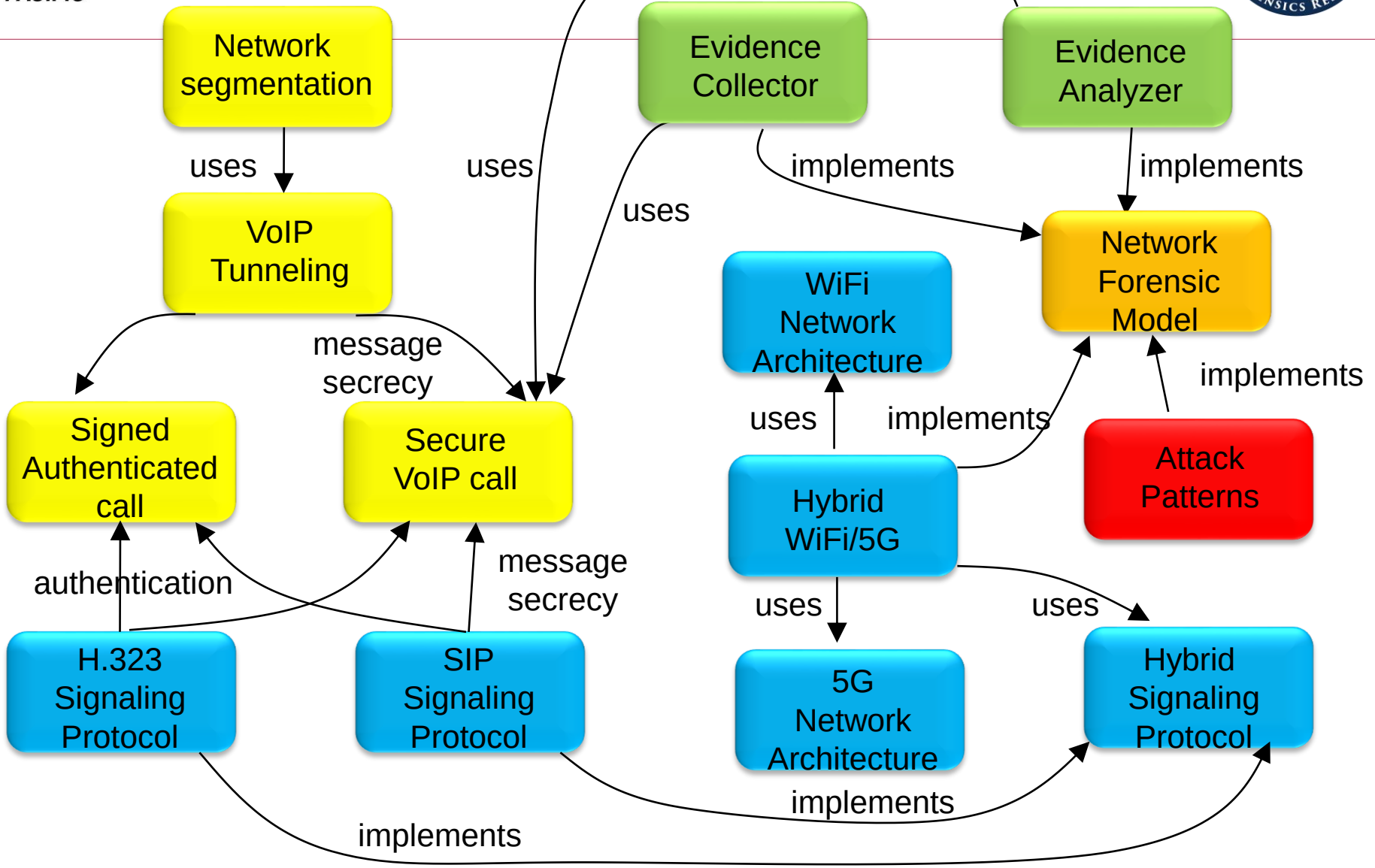
UC Pattern System

- **Architectural patterns**
  - Analyze cloud-based converged architectures in UC**.**
  - Focus on modeling enterprise architectures using semi-formal models.
  - Patterns are used for high-level specification of the UC system.
- **Attack patterns**
  - Systematic description of the steps/goals of an attack and ways to defend and trace its application in a system.
  - Attack pattern template to describe how to document and organize generic attack patterns.
  - Attack pattern catalog.
- **Security patterns**
  - Based on security mechanisms/standards to stop attacks against the UC system.
  - Understand what security patterns are necessary to prevent or mitigate the threats.
- **Forensic patterns**
  - Capturing, recording, and analyzing information collected on UC networks from several intrusion detection, auditing, and checking points.
  - Help network investigators to select relevant evidence

UC Pattern System



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Network Forensics Patterns

- Network forensics adds another dimension of protection to the system.
- Need for systems that allow not only the detection of complex attacks, but understanding the attack, and collecting enough evidence of these crimes.
- The collection of media packets in real time and the use of automatic mechanisms are fundamental.
- Forensic Patterns provide an abstract view of forensic information to network investigators.
- Goal: enable a faster response and more structured investigations of network attacks.
- Discover the source of security breaches

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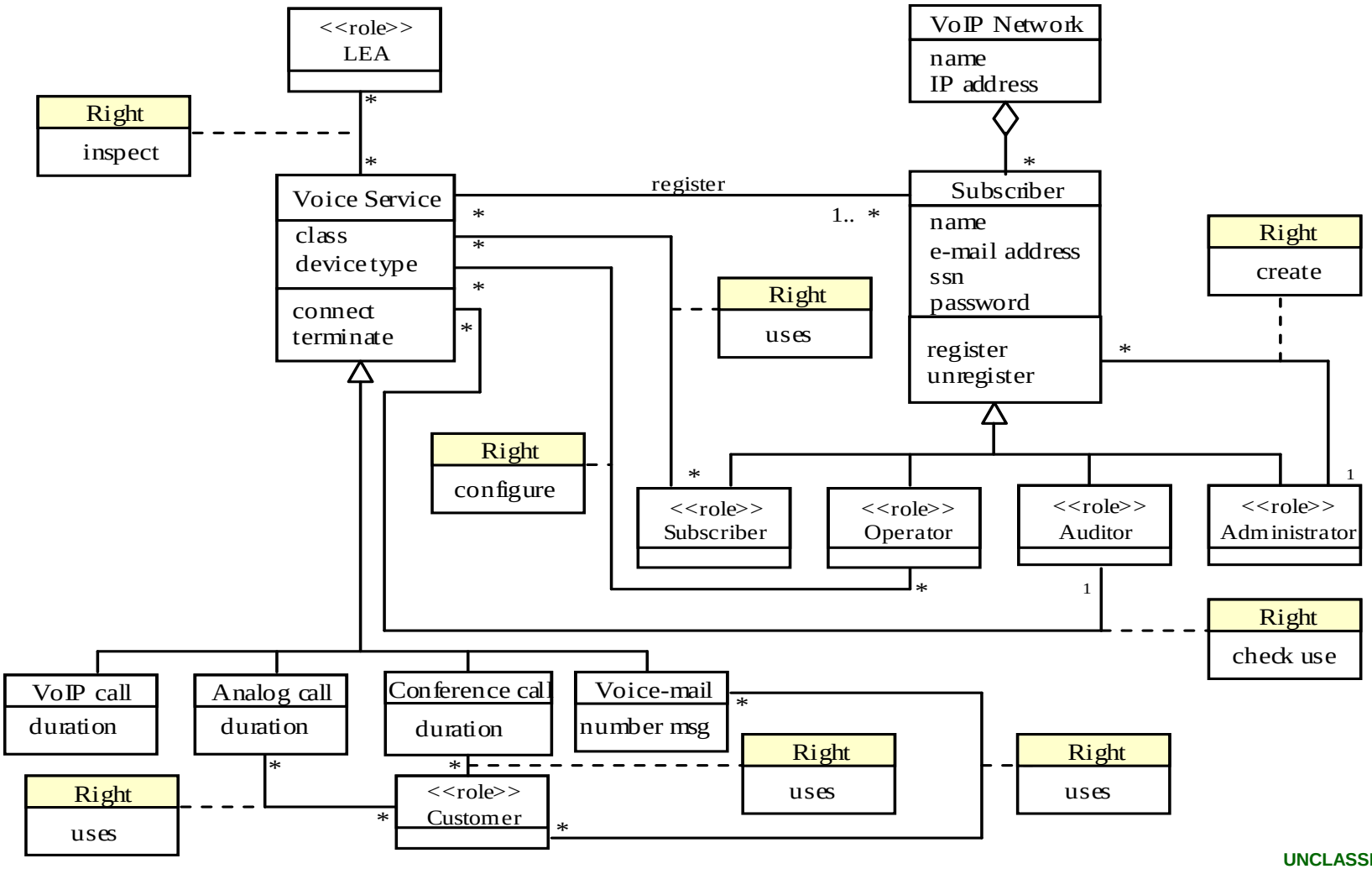
Roles and Rights in UCaaS Model



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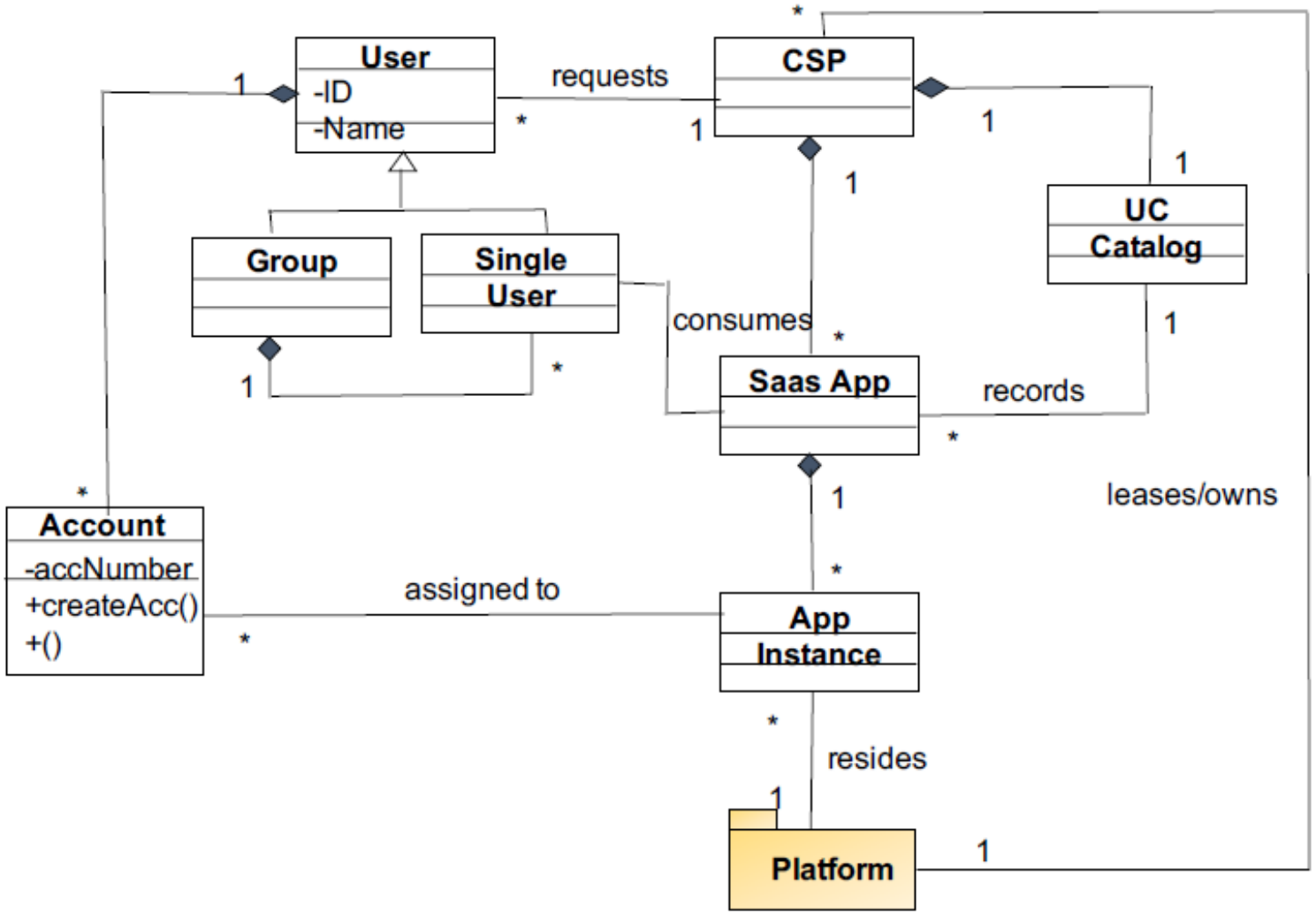
Class Diagram for UCaaS Pattern



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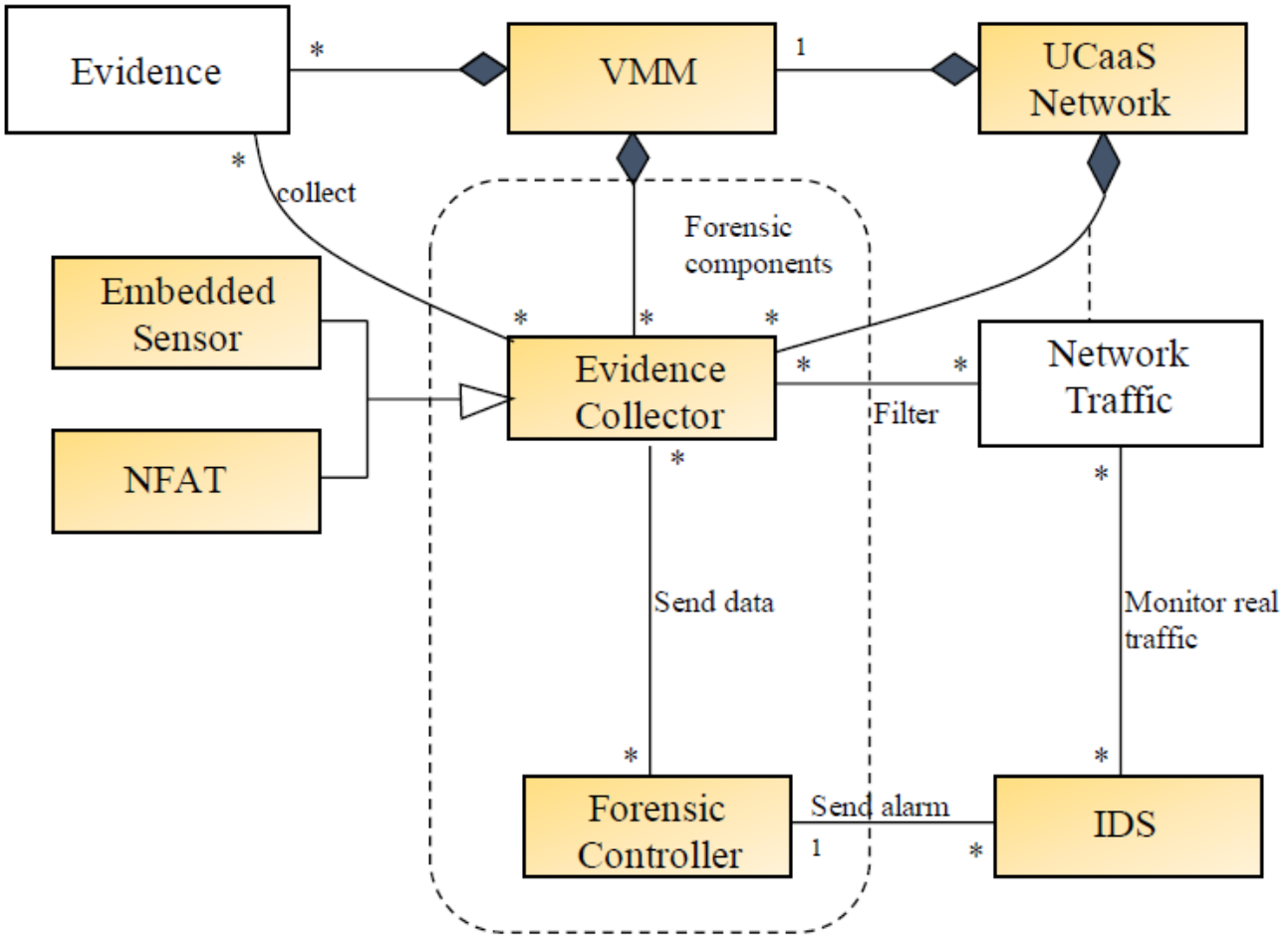
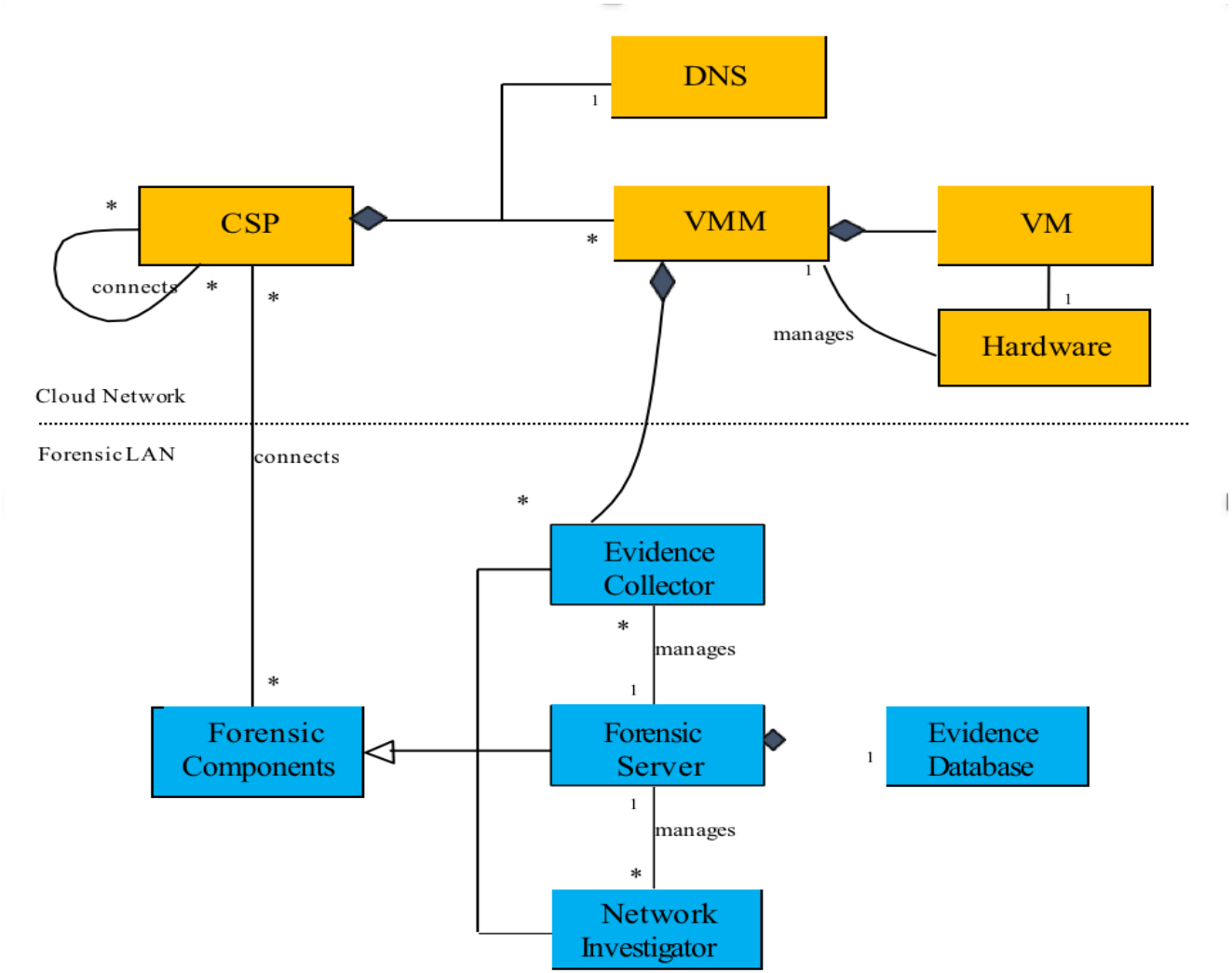
Cloud Evidence Collector



Simplified Cloud Forensic System Architecture



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Cloud Forensics System

- Develop autonomic UCaaS forensic system including novel forensic tools and methods to conduct live forensic investigations.
  - Expand existing cyber forensic capabilities at CFRL.
  - Testbed to include set of voice, video and data-sharing capabilities
  - Complexity/dynamic behavior of converged network systems
- Analyze the identification, collection and analysis of forensic evidence in converged cloud environments (VVoIP).
- Develop UCaaS testbed to create high-fidelity simulations of existing and future Navy communications architectures.

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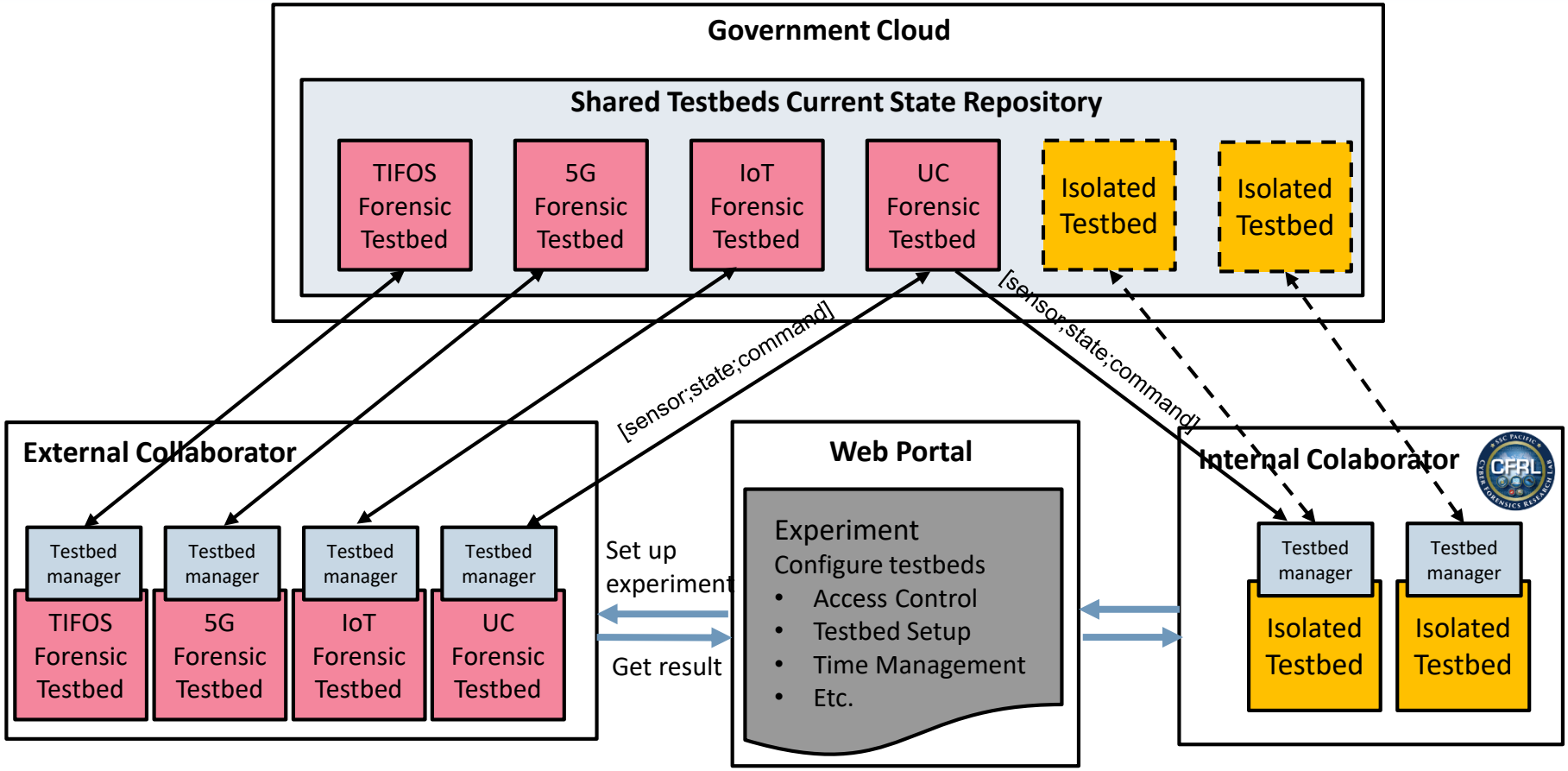
CFTaaS Objective

- Develop cloud-based system to experiment with and evaluate different tools and techniques to detect, collect and analyze forensic evidence in near real-time.
- Develop federated cyber forensic testbed to evaluate different cyber forensic techniques and tools to detect and protect enterprise infrastructures and their services
- Analyze the identification, collection and analysis of forensic evidence to address the next domain of cloud forensics.
- CFTaaS system designed to provide self-defense mechanisms (immune) against non-self (i.e., malicious intruders) within a cloud environment for optimized approach.
- Protect smart infrastructures and their services from malicious cyberattacks, faults or accidents.
- Support network investigators to identify actual intrusions, collect more and better evidence, reduce analysis time, and help to stop attacks against the enterprise network.

CFTaaS Concept Architecture



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CFTaaS Benefits

- Develop innovative training cyber forensic experiments, provide hands-on experiences.
- Provide service oriented architecture to publish forensic and security experiments for research and training.
- Automated method for identification, collection and analysis of forensic data to conduct live cyber forensic investigations.
- Access geographically dispersed heterogeneous testbeds and maintain privacy of users and their experiments running on cross-domain resources.
- Explore innovative techniques to overcome research challenges of developing a multi-domain collaborative and federated cyber forensic testbed environment.

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Conclusions

- Model-based CFTaaS approach lays the foundation for future practical work.
- Automation increases forensic soundness of the data-acquisition process by making it repeatable and not dependent upon manual and possibly error-prone human interactions.
- Implement live forensics as a secure and convenient method of collecting/analyzing digital evidence in converged environments.
- Patterns can guide systems development, be used to evaluate existing designs, be a basis for simulation, and be a pedagogical tool.
- Creation of a comprehensive pattern system to be used in forensic investigation processes.
- Concentrated on pattern functionality/usefulness. First steps toward a methodology for modeling digital forensics.
- Potential to be used as evidence. Forensic patterns value may be realized when semi-formal models are reused on similar investigations.
- Semiformal models introduced to address unique challenges of digital forensics based on sound principles but still require extensive scientific validation in practice.

Moving Forward

- Strong demand for Cyber security and forensics
- Development of automated network forensic systems using modeling and simulation approaches.
- Collaborations with other disciplines to develop new tools enhance existing forensic frameworks.
- Analyze new and evolving network attacks. Expand attack pattern catalog.
- Design new tools for better evidence collection/analysis (e.g. network behavior analysis).
- Proactive vs. reactive network
- Live-forensics vs. post-mortem
- Innovate, Integrate, Interoperate

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