



# Crucible

A Cyber Experimentation and Exercise Framework



# Introducing Crucible



**CRUCIBLE** is an open-source application framework for operating a cyber range. Crucible aims to be both simple and powerful, highly extensible, and cost effective.

Since 2018, Crucible has effectively enabled large-scale Department of Defense (DoD) cyber exercises to increase operator performance. Crucible is now available to the public under open-source licensing.

## Key Features

- Open-source cyber-range application framework
- Modular design with extensive application programming interfaces
- Customizable, immersive, browser-based user interface
- “Infrastructure as code” approach to topology building—enabling scalability, iteration, and reuse
- Flexible integration of powerful, third-party, open-source tools
- Scenario-based exercising
- Efficiency through automation
- Interoperability through open standards

## Addressing Persistent Challenges

Cyber range administrators confront persistent challenges:

- manual configurations leads to high-labor costs and excessive human error—with limited scalability and automation
- proprietary range software leads to vendor lock-in and increasing costs

CMU SEI developed Crucible in response to a decade of experiencing these frictions.

## Automating Cyber Experimentation and Exercise

Crucible automates creation of virtual cyber environments featuring modeled topologies, simulated user activity, and scripted scenario events. These environments power individual labs, team-based exercises, and operational experimentation. These simulations can be fully automated or facilitated. Crucible content developers create new templates by specifying a topology, scenario, assessments, and user interfaces. Participants are challenged to perform mission-essential tasks and individual qualification requirements. Each Crucible application is built using the open-source Angular and .NET Core software frameworks.

## Designing User Interfaces



Crucible’s **Player** application is the user’s window into the virtual environment. Player enables assignment of team membership as well as customization of a responsive, browser-based user interfaces using various integrated applications.

A Crucible system administrator can shape how scenario information, assessments, and virtual environments are presented through the use of integrated applications.

### Open-Source Integrations:

- **osTicket**, a support ticket system, manages cyber range service requests.
- **Mattermost**, a chat service for real-time communications.
- **Rocketchat**, a chat service for real-time communications.
- **Roundcube**, an email service, provides web-based email.

## Coding a Topology



Crucible’s **Caster** application enables the “coded” design and deployment of a cyber topology. Using Caster Designs, a novice content developer can avoid scripting OpenTofu code by simply defining variables within pre-configured OpenTofu modules.

Caster supports the design and deployment of virtual environments to three types of hypervisors: VMware vSphere ESXi, Microsoft Azure HyperV (public-cloud, and Proxmox Virtual Environment KVM (open source).

### Open-Source Integrations:

- **OpenTofu**, an “infrastructure-as-code” tool, enables scripted deployment of cyber infrastructure.
- **GitLab**, a version control system and code-repository, is used to store OpenTofu modules.

## Crafting a Scenario



Crucible’s **Blueprint** application enables the collaborative creation and visualization of a master scenario event list (MSEL) for an exercise. Scenario events are mapped to specific simulation objectives.



Crucible’s **Steamfitter** application enables the organization and execution of scenario tasks on virtual machines.

### Open-Source Integrations:

- **StackStorm**, an event-driven automation platform, scripts scenario events and senses the virtual environment.
- **Ansible**, a software provisioning, configuration management, and application deployment tool, enables post-deployment provisioning of services to infrastructure.

## Modeling the Internet



Crucible's **Greybox** virtual machine provides the illusion of connectivity to the real Internet: a realistic BGP backbone topology with point-to-point link delays based on physical distance between the routers' real-world locations, combined with application services (HTTP, DNS, email, etc.).

### Open-Source Integrations:

- **CORE (Common Open Research Emulator)**, a tool for building virtual networks that run in real time.

## Animating Activity



Crucible's **GHOSTS** Non-Player Character (NPC) automation and orchestration framework deploys and shapes the activities of NPCs using Generative AI models.

### Open-Source Integrations:

- **Ollama**, a platform designed to run Llama 2, mistral, and other open source large language models locally on your machine.

## Evaluating Threats



Crucible's **Collaborative Incident Threat Evaluator (CITE)** application enables participants from different organizations to evaluate, score, and comment on cyber incidents. CITE also provides a situational awareness dashboard that allows teams to track their internal actions and roles.

## Displaying Incident Information



Crucible's **Gallery** application enables participants to review cyber incident information based on source type (intelligence, reporting, orders, news, social media, telephone, email) categorized by critical infrastructure sector or any other organization.

## Assessing Performance



Crucible's **SEER** application enables assessment of team performance. Assessment reports map training objectives to scenario events to performance assessments.

### Open-Source Integrations:

- **Moodle/H5P**, an interactive learning management system, eases the embedding of interactive quiz content. Assessments and other user-experience data can be recorded to a learning record store using the Experience API (xAPI).
- **TheHIVE**, a scalable security incident response platform, is tightly integrated with the malware information sharing platform (MISP).

## Launching a Simulation



Crucible's **Alloy** application enables users to launch an on-demand event or join an instance of an already-running simulation. Following the event, reports can provide a summary of knowledge and performance assessments.

## Operational Deployment

Crucible applications implement the OpenID Connect authentication protocol and are integrated with **Keycloak**, an open-source identity authentication service.

Crucible applications are deployed as **Docker** containers, which employ operating system level virtualization to isolate containers from each other. Container deployment, scaling, and management services are obtained using **Kubernetes**, a popular container-orchestration system. Kubernetes workflow and cluster management are performed using **Argo**, a popular open-source GitOps toolset.

A pre-configured Crucible Appliance virtual machine is available for download.

Beyond government-owned instances, the SEI owns and operates on-premises and cloud-based instances of Crucible:



**Fortress**  
fortress.sei.cmu.edu




**Gauntlet**  
gauntlet.sei.cmu.edu

## Learn More

To learn more, see the full documentation at [cmu-sei.github.io/crucible/](https://cmu-sei.github.io/crucible/) and [cmu-sei.github.io/GHOSTS/](https://cmu-sei.github.io/GHOSTS/).

For more information, email [info@sei.cmu.edu](mailto:info@sei.cmu.edu).





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