Electronic Preprint for Journal of Information Processing Vol.27

Invited Paper

Scenargie as a Network Simulator and Beyond

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Received: May 10, 2018, Accepted: October 29, 2018

Abstract: This paper presents Scenario Generation and Management Framework for in-Depth Analysis and Extended Control, or simply Scenargie, for the analysis, evaluation and control of various networked systems. It was originally developed as a wireless network system simulator, and has significantly extended its target systems and capabilities for over a decade. This paper gives an overview of Scenargie and its primary modules with several use cases, and describes its simulation models and their fidelity. It also presents its system control capability recently added as part of its evolvement with two demonstrative projects.

Keywords: system evaluation, system control, wireless network systems, network simulator, modeling and simulation, IEEE 802.11, intelligent transportation system (ITS)

1. Introduction

Scenargie (pronounced as "synergy") is a scenario generation and management framework for various systems to be analyzed, evaluated and/or controlled, where a "scenario" in its name refers to a collection of various data, including state changes so-called "events" and geometry data in and around the target system. It was originally developed for evaluating wireless network systems, but has later been extended to evaluating larger systems, of which networking is only a functional part.

The original version of Scenargie was created by the authors of this paper, some of whom have designed and implemented Parallel Simulation Environment for Complex Systems (PARSEC) [1] and Global Mobile Information Systems Simulator (GloMoSim) [2] at UCLA in the late 1990's. However, no piece of code has been shared between PARSEC/GloMoSim and Scenargie. While both can simulate wireless network systems, they are designed to achieve disparate objectives with different emphases.

Scenargie has been built from scratch in C++ and the Boost libraries [3] after Space-Time Engineering, LLC was founded in May 2007. Its name originally stood for "Scenario Generation and Management Framework for in-Depth Analysis and Evaluation." As it has evolved to become capable of not only evaluating but also controlling the target system based on its data analysis, the latter part of its name is changed to "for in-Depth Analysis and Extended Control" to indicate the addition of its new capability.

Scenargie is used for both industrial and academic purposes, and more than 200 licenses of Scenargie have been sold in the United States and Japan. Further, it has been cited over 100 international papers, and many of them extensively use it for the wireless system evaluation in their research studies. Among those papers, three papers [4], [5], [6] cited by other researchers the most study wireless networks for vehicular communications or Intelligent Transportation System (ITS), which are indicative of a strong support by the corresponding research community.

This paper is organized as follows. It gives an overview of Scenargie and its primary modules in Section 2, followed by the description of its simulation models and their fidelity in Section 3. Section 4 discusses differences between Scenargie and other common network simulators, and Section 5 explains its features as a system control platform with two demonstrative projects in Kochi Prefecture of Japan. Section 6 concludes this paper with a plan on further Scenargie evolvement.

2. Architecture of Scenargie

2.1 Scene Manager

Scenargie is originally aimed at a new system evaluation framework, which allows network designers to perform their system evaluation effectively without having to spend a significant amount of their time and effort. The motivation behind this lies in the fact that planning of a realistic system evaluation, or creating an effective evaluation scenario, is very time consuming. It involves extensive efforts to collect measurement data in the field, analyze, and compile them with other data in a statistically meaningful manner. In particular, collection of measurement data in the field is the most time consuming task even though it is necessary and highly important. Field measurements for the wireless network system evaluation often include but not limited to:

- GPS coordinates of each device (or the trace of them in case it is mobile) in the system.
- Geographical Information System (GIS) data such as a street map, elevations, dimensions of buildings around the system.
- Application traffic offered by each user of the system.
- Traffic load generated or given to each location in the system.

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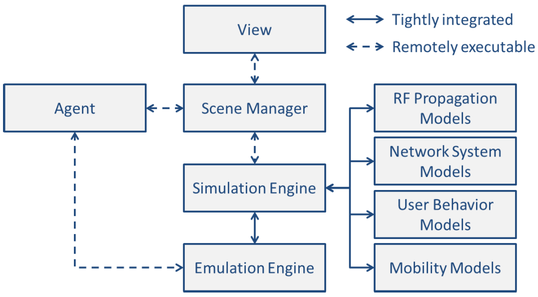

Fig. 1 Overall organization of Scenargie.

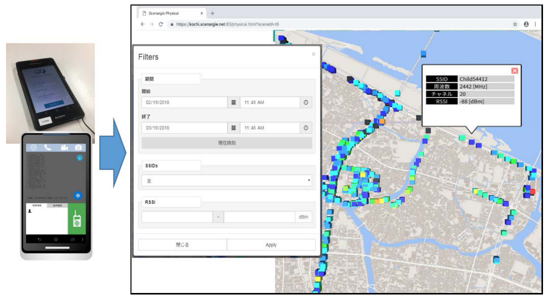

Fig. 3 Collection of RSS data using an Agent.

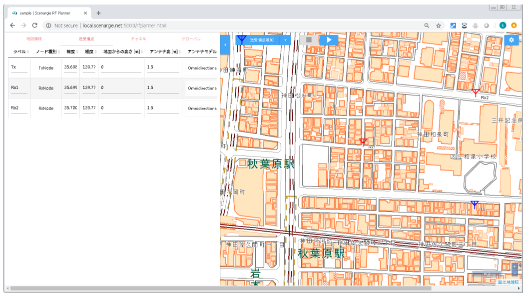

Fig. 2 A screenshot of the View running in a web browser.

- Received Signal Strength (RSS), Signal to Interference and Noise Ratio (SINR), and Packet Error Rate (PER) for the given traffic load at each wireless receiver in the system.
- Resulting end-to-end throughput and latency for each application session in the system.

The Scene Manager builds a database called a "scene" by gathering all the measurement data above and any derived data as a result of data analysis. It makes the scene data available for performing the system evaluation or validating simulation models against the target system, such that its users can focus on their systems of interest and have more time to conduct other necessary tasks in the system development and deployment processes.

Figure 1 shows the overall organization of modules provided by Scenargie. The Scene Manager plays the central role as it manages the scene data to be fed to or gathered from the other modules within its framework. The following subsections describe other primary modules of Scenargie shown in the figure.

2.2 View

"View" is a graphical user interface of Scenargie that displays various data stored in the Scene Manager. It is a necessity for any data with a spatial attribute as they are highly difficult to interpret or understand without some form of graphical representation.

Figure 2 is a screenshot of the View that shows a geographic map where the target system is located. The latest version of the View can be called remotely over a network to access the scene data in the Scene Manager using a web browser.

2.3 Agent

In order for the Scene Manager to gather measurement data to compose a scene automatically, multiple instances of "Agent" in the field are necessary for collecting sensor data or performing on-site measurements, based on the rules predefined by the evaluation scenario.

Figure 3 shows an Agent implementation that scans the Wi-Fi [7] channels and collects Service Set Identifiers (SSIDs) with associated RSS values from Access Points (APs) in the field [8]. The data collected by an Agent is transferred to the Scene Manager to be viewed on a map or analyzed to assess the number of APs, their coverage of the area, etc.

The features provided by the Agent have made Scenargie deviate from other system evaluation frameworks, and become capable of being used as a system control platform; the Scene Manager gathers data from Agents and sensors in the field, statistically analyzes them, and gives feedback to the target system via Agents for the system control. Section 5 describes details on such usage of Scenargie with two demonstrative projects.

2.4 Simulation Engine

"Simulation Engine," together with associated simulation models, is the primary component of system analysis provided by Scenargie. It is commonly used in an early stage of wireless system development when the target system does not exist yet, but it is also used even if the target system does exist and is accessible to perform experimental tests. This is because wireless communication is highly probabilistic and requires a significant amount of measurements to obtain statistically valid experimental results. Also, real Radio Frequency (RF) propagation environments can be impractical to control even though they can severely affect the wireless system performance.

In contrast to the physical experiment, simulation can produce the same results repeatedly with the same random number sequence, and easily control the virtual RF propagation environment. It can also be used for the system evaluation under situations that infrequently occur in reality, such as detection of system anomalies, system behaviors when a disaster strikes, etc.

Please note, however, that the simulation of the target system and the surrounding environment needs to be as close to the reality as possible in order for the simulation results to be meaningful. Therefore, the Simulation Engine and associated models leverage simulation scenarios in the Scene Manager that are derived from the measurement data collected in the field. Section 3 describes Scenargie as a wireless network simulator in more detail.

2.5 Emulation Engine

"Emulation Engine" is often used in later stages of system development when operational system codes of the target system are available for use in the system evaluation. By utilizing operational codes instead of simulation models, it can omit the model-

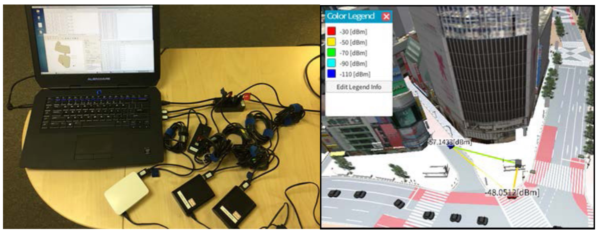

Fig. 4 Emulation of a V2X communication system.

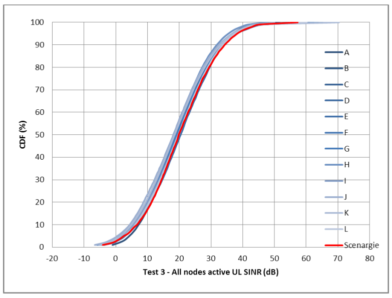

Fig. 5 Box 2 Simulation Scenario 1 calibration data [20] (Test 3 – CCA turned on, Uplink Effective SINR [dB]).

ing of some system components for the system evaluation, which is useful as modeling a wireless network system appropriately for given evaluation objectives is a challenging task. Also, it is highly effective when it is difficult to run a physical experiment in the field where the mobility of multiple vehicles can be difficult to control.

Figure 4 shows an emulation experiment using Scenargie for evaluating a Vehicle-to-Everything (V2X) communication system. The picture on the left shows the physical configuration of the emulation, in which the Scene Manager, the Emulation Engine, the Simulation Engine, and simulation models for RF propagation and mobility are running on the laptop, while operational codes for the vehicles are running on the three Raspberry Pi (RPi) devices, connected to the laptop via USB cables.

The picture on the right is a screenshot of the View displaying the target environment, where the effects of RF propagation and mobility of vehicles are virtually created by simulation. The operational codes running on the RPi devices are given virtual coordinates computed by the mobility model in the simulation, and behave as if they were in the simulated environment. A packet transmitted by one of the RPi devices can be received by the others only when the RSS values computed by the RF propagation model are high enough to be detected by them.

In this experiment, an Agent also runs on each RPi device and generates synthetic application traffic whose amount and timing are specified in the evaluation scenario managed by the Scene Manager. It also measures the throughput and the end-to-end latency of application traffic, and the results are transmitted to the Scene Manager when the evaluation scenario completes. The automation of application traffic generation and measurement is essential to perform this kind of emulation experiment.

3. Scenargie as a Network Simulator

3.1 Wireless Network System Models

Scenargie offers a wide variety of wireless system models including but not limited to the following:

- IEEE 802.11 and its amendments (a/g/n/ac/ax), commonly known as Wi-Fi.
- Wireless Access in Vehicular Environment (WAVE)/ Dedicated Short Range Communication (DSRC), or a set of standards defined as IEEE 802.11p, IEEE 1609 [9], [10] and SAE J2735 [11].
- 3GPP Long Term Evolution (LTE) with an option of License Assisted Access (LAA) and Cellular V2X (C-V2X) [12], [13].
- Bluetooth Low Energy (BLE) [14].
- Long Range (LoRa) [15] as a Low Power Wide Area (LPWA) categorized device.

It also provides other simulation models for higher layer system components including routing protocols and application programs. A part of its TCP/IP protocol model is a piece of operational code in the FreeBSD operating system [16].

Please note that a rich set of simulation models has little value unless they are somehow validated and regarded as "accurate." The accuracy of a simulation model, however, depends on the fidelity of the model for the given simulation objectives, and may vary even though it is for the same model. The most important factor to determine the fidelity of a simulation model for the particular objectives is the amount of validation effort put in it, i.e., how much the simulation results from the model are compared against the measurement data from the target physical system, or how much they are compared and calibrated against results from other simulation models for an identical simulation scenario. The former is commonly referred to as the validation of the simulation model, while the latter as the cross-validation of the model.

Cross-validation becomes the only viable solution when the target physical system is not available, accessible, or easily controllable for the validation. In the simulation based wireless system evaluation, the most extensive cross-validation work can be found in the 3rd Generation Partnership Project (3GPP) [17], which develops specifications for advanced mobile communication systems. Since its participants are unable to share their simulation models due to intellectual property issues but need to compare and evaluate their proposals on the system specifications, calibrating their simulation results and produce the same results on the baseline system performance is critical.

Another similar cross-validation effort can be found in the activities of High Efficiency Wireless LAN at Task Group ax (TGax) [18] of the IEEE 802.11 Working Group [19]. Since some of the authors of this paper have been involved in its standardization activities for over a decade, IEEE 802.11 simulation models in Scenargie have been used in the TGax cross-validation work [20]. The cross-validation is performed with 4 different simulation scenarios (i.e., residential, enterprise, indoor small scale and outdoor large scale deployments) in 5 levels of system scope (physical layer, medium access control sub-layer, both, etc.) called "Boxes." Documents describing details of its evaluation methodology, simulation scenarios, and calibration results are all available at https://mentor.ieee.org/802.11/documents [21], [22], [23].

Figure 5 shows a set of Box 2 calibration data that plots the cu-

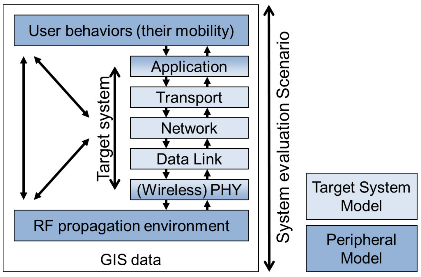

Fig. 6 Composition of target system and peripheral models in an evaluation scenario.

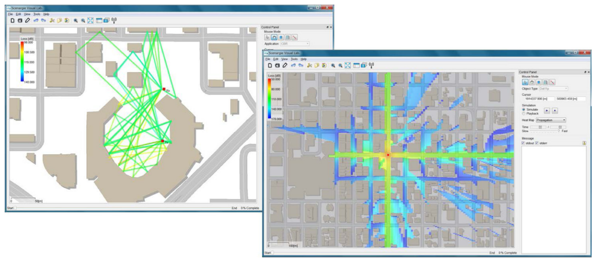

Fig. 7 Scenargie High Fidelity Propagation Module.

mulative distribution function (CDF) of the effective SINR for the uplink traffic in Simulation Scenario 1. The thirteen lines in the figure represent the simulation results contributed by 13 different participants without sharing their simulation models. As shown, their curves are liked up to each other with a maximum difference of 2.3 dB at the 50 percentile. The red line represents the simulation results from the standard package of Scenargie, which is in agreement with other results. This indicates that the IEEE 802.11 simulation models included in Scenargie are accurate for this kind of simulation objectives.

3.2 Peripheral Models for the Target System Evaluation

Figure 6 shows various models that compose a simulation scenario for the wireless network system evaluation. The models in light blue are for the target network system, surrounded by the models in darker blue that interact with them called "peripheral models." The models with a gradient blue are either part of the target system or peripheral, depending on the objectives of system evaluation.

While simulation models for the target network system are often carefully inspected on their fidelity, peripheral models tend not to be paid close attention. However, their effects on the simulation results are significant, and sometimes even greater than the effects by the target system models. Also, building peripheral models is more difficult than that of target system models, as doing so requires not only expertise outside of network engineering field, but also understanding of bidirectional interactions with the target system to be evaluated.

In the following, details of two important peripheral models, i.e., RF propagation and user behaviors (including their mobility), are described.

3.2.1 RF Propagation Models

While simulation of RF propagation is essential for both design and deployment of the wireless systems, networking researchers tend to lack expertise in this crucial field. Assuming a disk communication range used for the asymptotic analysis of wireless networks would certainly mislead the expected performance of wireless networks deployed in the field.

Scenargie provides the following RF propagation models for the evaluation of wireless network systems:

- Path loss models: free space, simplified two-ray ground reflection, indoor wall count, Okumura-Hata, Longley-Rice, ITU-R P.1411 (urban canyon) [24].
- Shadowing models: log-normal shadowing.
- Fading models: Rayleigh, Ricean, frequency selective fading (based on the Jakes model).
- MIMO model (including all of the above features): IEEE 802.11 TGac channel model [25].

In addition to the models above, Scenargie offers two optional high fidelity ray-trace based propagation models in cooperation with Remcom, Inc. [26]: High Fidelity Propagation Module (HFPM) and Fast Urban Propagation Module (FUPM). The former performs the full three dimensional ray-trace simulation for high fidelity results, while the latter limits the ray path search area in order to improve the runtime performance at the expense of losing modeling fidelity in certain propagation environments.

Figure 7 shows two screenshots of the View displaying the results produced with HFPM in two simulation modes; the one on the left shows multiple ray paths between the two red points on the map (point to point simulation mode), and the other is a heat map of path loss values from the location at around the center of the map (point to multi-point simulation mode). All the other path loss models in Scenargie can also be run in these two modes, depending on the objectives of the simulation based analysis.

Please note that the ray-tracing is regarded as one of the highest fidelity models for the RF propagation, which is accurate only when it is given high precision data that represent the area to be analyzed. Inaccuracies in the simulation results can easily be caused by errors in object dimensions in the GIS database, or terrain features not traditionally included in the database. Supplementing the simulation results with measurement data via the Scene Manager is crucial in order to create a realistic evaluation scenario.

3.2.2 User Behavior Models

Modeling behaviors of wireless network users is another difficult task for networking researchers. The user behavior models have significant impacts on the predicted performance of the target system, as they can determine the amount of application traffic and possibly the network topology.

Scenargie models user behaviors as a Multi-Agent System (MAS) [27], in which multiple agents in the scene decide their actions individually based on the predefined rules and the knowledge available to them without a centralized controller in the system.

Figure 8 shows a simulation scenario in which the MAS based user behavior model is used for the evaluation of a disaster resilient wireless system [28]. The simulation scenario includes about 10,000 agents (red dots in the figure) in the area around the Sendai rail station in Miyagi Prefecture of Japan.

In this evaluation scenario, people behave ordinarily at the beginning of simulation; once an earthquake strikes the region,

Fig. 8 Simulation of user behaviors using a MAS model.

those who are outside of the buildings start moving towards the nearest evacuation site on foot, which may or may not be able to accommodate them depending on its capacity. They keep moving until they find the site with some capacity available.

The evaluation scenario is comprised with two cases as shown in the figure, with and without the target wireless network system that regularly disseminates the list of evacuation sites that can still accommodate people. Except for the existence of the target system, these two cases are identical. Since people without any site status information may unnecessarily visit the sites that have already reached their capacity, the completion time is shorter with the target system, but it is unclear as to how much the system can shorten the completion time.

In this evaluation, the effectiveness of the target system is directly measured as the completion time for all the people to find the site to evacuate to. This direct measure of system effectiveness cannot be accomplished without a MAS based user behavior model; without the model, the evaluation metrics could be the latency of information dissemination or the network capacity, neither of which may have a clear correlation with the system effectiveness.

4. Comparisons with Other Network Simulators

4.1 Accuracy of Simulators and Simulation Results

As Scenargie started as a wireless network system simulator, it is frequently compared against other network simulators such as ns-2 [29], ns-3 [30], and QualNet [31], particularly on their accuracy. However, the accuracy of a network simulator is quite different from that of simulation results, and their definitions need to be clarified.

A network simulator or a discrete event simulator processes a sequence of events that change the state of the target system. By sequentially executing the event with the earliest timestamp in the event queue, it processes all the events occurred during the simulation in chronological order, which maintains causality or the fact that a change in future never affects the present or past state of the system. A network simulator is said to be accurate as long as it avoids any causality error during the simulation execution.

For the accuracy of commonly used network simulators, almost all the network simulators are accurate, except for ns-2 that uses a double precision floating point variable to represent the simulation clock. As its clock can hold only 15 significant digits, the simulator starts to lose the time precision of 1 nanosecond (10^{-9} [s]), or 0.3 meters of RF propagation latency, when the simulation duration exceeds 11.6 days (10^{6} [s]), although this would not be a problem for many simulation scenarios.

The accuracy of simulation results, on the other hand, is not guaranteed even if the network simulator used is accurate; instead, it highly depends on the fidelity of simulation models as described in Section 3.1. Simulation results are accurate only when the simulation is performed with an accurate network simulator and high fidelity simulation models for the given simulation objectives.

As a commercial simulator, Scenargie offers high fidelity simulation models of both wireless network and their peripheral systems for common simulation objectives. This contrasts with open source network simulators contributed by networking researchers, whose expertise and interests are naturally focused only on the network systems to be evaluated. The fidelity of peripheral simulation models in those simulators tends to be low as a result, regardless of the size of the supporting research community.

One of such instances can be found in the IEEE 802.11 physical layer models of ns-2, which had the largest supporting community for an open source network simulator. Those models were built, validated against small scale experiments, and contributed to the corresponding community when the IEEE 802.11 devices were operating at 914 MHz rather than the current 2.4 GHz [32]. Several modeling issues as well as their impacts on the evaluation of higher layer networking protocols have been reported in 2001 [33]; however, many of them have been left unaddressed until its development ceased in 2010, due to the lack of voluntary effort within the supporting community.

4.2 Licensing of Simulators

Further, it is imperative to mention that many of the cross-validation results shown in Fig. 5 are yielded using ns-2 or ns-3, but simply executing those simulators without any modification will not even come close to yielding the simulation results in the figure; their standard packages even miss the channel models necessary for the evaluation scenarios. The reason behind this is closely coupled with the licensing terms of these network simulators.

Both ns-2 and ns-3 are open source software, and adopt the GNU General Public License version 2 (GPLv2) [34] that mandates any distribution of modified software or derivative work to be freely available to anyone in the source form without an exception. This actually prevents cross-validation participants from reflecting their fixes and improvements back to the original system model codes, as they are most likely tied with their technologies not to be shared with others. Therefore, the use of these open source simulators merely means the use of their event schedulers, not the models included in their standard packages. This absence of user feedback often causes a misunderstanding of the fidelity of simulation models included in those simulators.

The IEEE 802.11 models included in the standard package of Scenargie have been cross-validated, and yield the results shown in Fig. 5 without modification. Also, all of its simulation models are made available to users in the source form, such that the simulation models can be inspected, verified, or modified for certain simulation objectives by the users, like the open source software.

5. Scenargie as a System Control Platform

As mentioned previously, the current version of Scenargie can be used not only as a system evaluation framework but also as a system control platform. Instead of using gathered data in the field for the analysis and evaluation of the target system, it can give feedback to the target system based on the data analysis through Agents or actuators in the field, and effectively control the target system behaviors.

While this new feature was initially added as a small extension, it has changed both the purpose and the end users of the software substantially. Since there might be different or additional functional requirements to the software as the system control platform, the authors of this paper took a participatory design approach, in which system developers, operators, and end users are all involved in the system design process such that Scenargie can meet all the requirements to be regarded as a useful system control platform.

Scenargie used as the system control platform is called "Scenargie Physical" to distinguish from its original usage as the system evaluation framework. The following subsections describe two of such Scenargie Physical projects in Kochi Prefecture of Japan.

5.1 Electronic Triage System

The first project of Scenargie Physical started in collaboration with Kochi Chuo Higashi Public Health and Welfare Office in Kochi Prefecture of Japan in 2016. The coastal area of Kochi Prefecture is projected to be severely damaged by Tsunami once a large scale Nankai Trough earthquake hits the region. Many cities and towns are executing various drills to increase the preparedness of their residents for such disastrous situations.

One of the drills performed by the collaborator is to open a first aid station in front of the emergency room of medical care facility, where local doctors and nurses triage the injured to increase the effectiveness of their treatments. However, the workflow defined in the drill held in Nankoku City in December 2015 turned out to be dysfunctional, or at least very ineffective. Assuming that neither the Internet nor cellular service may be available, the drill used only paperwork to record and share patient information. However, the first aid station was too large for messengers to carry the papers around.

After several meetings with intense discussions, an electronic triage system based on Scenargie Physical has been introduced in a similar drill held in Konan City in Feb. 2017, and has functioned successfully for recording and sharing information within the first aid station [35]. **Figure 9** shows the layout of the triage system that connected 7 locations in the first aid station and a location at the Emergency Room of Noichi Chuo Hospital just across the street from the first aid station.

In this project, scene data in the Scene Manager hold patient records, including their conditions, sections in the first aid station, and priorities for medical treatments. As the system needs to assume no access to the Internet, cellular service, or even power grid, the system in the field is configured with a network of notebook PCs and tablet PCs connected via battery operated Wi-Fi APs. **Figure 10** shows a tablet PC and a battery operated AP actually used in the drill.

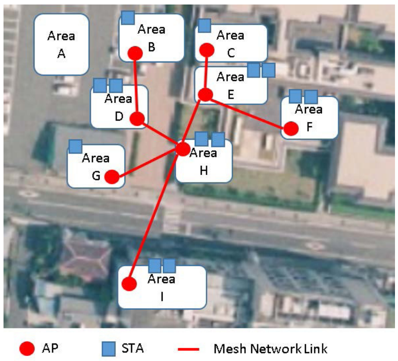

Fig. 9 Electronic triage system in the Konan City drill.

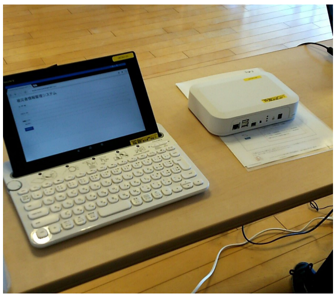

Fig. 10 Devices used in the Konan City drill.

Even though all the devices of the triage system are battery operated, a loss of data might occur due to device failure or unstable wireless connections between them. In order to avoid any loss of data, each AP maintains the scene data by running a Scene Manager independently, which forms a network of Scene Managers in the deployed system; The Scene Managers in the system regularly synchronize with others and update their scene data to the latest state. This would not have been required if Scenargie were used only as a system evaluation framework.

5.2 Disaster Resilient Communication System

The subsequent project using Scenargie Physical started with Konan City in 2017, and is currently ongoing. The purpose of the project is to deploy a disaster resilient wireless communication system not only in the coastal area of the city, but also in its inland and mountain areas. As the city is often hit by Typhoons, it anticipates a large amount of precipitation during late summer to early fall. As such, the types of disaster to be prepared for are storms, floods, and landslides that can easily shut down local roads and physically isolate small villages in the mountain area, in addition to the earthquakes considered in Section 5.1. Deployment of a city-wide wireless communication system that is resistant to various disastrous situations is the purpose of this project.

In this project, a network of the Scene Managers redundantly holds resident records as well as imagery data of damaged areas taken by Agents, which are shared with the disaster response headquarters at the city hall. **Figure 11** illustrates the overall network topology of the system currently considered.

As the extent of the area to be covered is too large to utilize Wi-

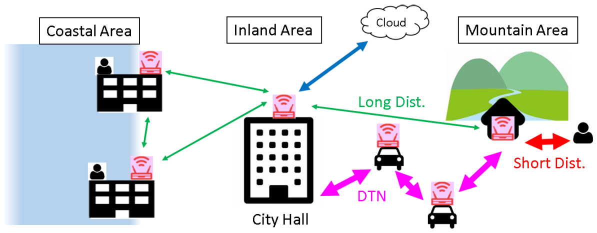

Fig. 11 Proposed architecture of the disaster resilient communication system.

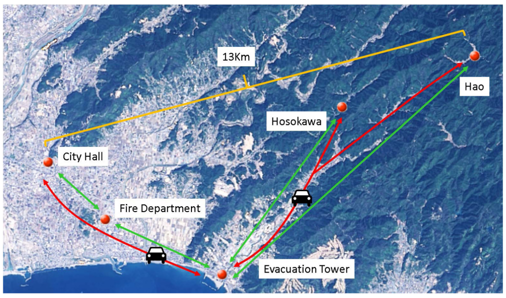

Fig. 12 Current deployment of the system in Konan City.

Fi APs only, the system selectively uses multiple wireless media, including Wi-Fi, LTE and Digital Convenience Radio (DCR) operating at different frequency bands, based on the size and the latency requirements of data to be shared. Further, Wi-Fi is also used as a means of configuring a Delay/Disruption Tolerant Networking (DTN) [36], which realizes end-to-end communications even with network partitions by storing and forwarding data at communication opportunities created by mobility of devices with data storage in the system.

Please note that wireless media operating at lower frequencies such as DCR can transmit data over long distances directly, while their data rates are too low to transmit high resolution imagery data. In the case where a large imagery needs to be urgently shared over a long distance, the Scene Manager makes a smaller transcoded imagery for DCR for immediate information sharing, and transmits the original imagery via DTN configured by the network of the Scene Managers. This allows relatively high speed sharing of emergency data through DCR while additional details are shared at a later time by DTN.

Figure 12 shows the system testbed currently deployed in the city. A Multi-access Edge Computing (MEC) [37] hardware system running a Scene Manager is installed at five locations shown in the figure: Konan City Hall, the Fire Department, a Tsunami evacuation tower, and two locations in the mountain area that are prone to be isolated by a storm. Further, two vehicles are equipped with the MEC system for data sharing at locations distant from those five sites as well as for the means of the DTN communication.

6. Concluding Remarks

This paper has described Scenargie, a software tool designed for the analysis, evaluation and control of various networked systems. Its use cases presented throughout the paper demonstrate the features provided by its primary modules, the fidelity of its simulation models, and the newly added capability as a system control platform.

Scenargie has substantially extended its capability and applicability for over a decade, and its enhancement will continue. As the system evaluation framework, it is planned to enrich the library of both wireless system models and peripheral models to cover a wider variety of systems to be easily evaluated. As the system control platform, it is still in its infantry, and needs to accumulate knowledge through more projects before becoming considered as a full-fledged system control platform. Its eventual goal is to make all of its system analysis and evaluation functionalities part of the system control platform for online analysis and control of the target systems.

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