Developing Performance Metrics of an Emergency Notification System

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ABSTRACT

The use of emergency notification systems (ENS), or early warning systems, are not only common practice among Institutes of Higher Education (IHEs), but are required by law in the United States. The dramatic increase in use is matched by the increase in community expectation. This community expectation corresponding with societal shifts challenges Public Safety leaders to implement and maintain a broad and highly reliable ENS. Most Public Safety programs lack the internal resources to consistently assess system risk, reliability, and messaging validity of their ENS sufficient to match the required system performance. Virginia Tech Emergency Management is proposing an ENS evaluation system capable of supporting assessment of reliability and risk across the entire system through the lens of Socio-Technical Systems (STS) theory at a practitioner level. By organizing emergency notification/early warning systems through Human Subsystems, Technical Subsystems, and Task Design the practitioner can assess their system by performance and risk.

Keywords

Emergency Notification System, Early Warning System, Socio-Technical Systems Theory.

INTRODUCTION

In 2015, Virginia Tech Emergency Management (VTEM) performed a routine test of their Emergency Notification System (ENS) when a particular delivery mode failed to perform as expected. According to the ENS testing protocol, an investigation into the delivery mode failure was conducted resulting in the identification of human error related to the delivery mode configuration. The investigation also revealed a subtle disconnect between Information Technology (IT) personnel responsible for the maintenance of the technical backbone of the ENS and the Emergency Management (EM) personnel responsible for the overall system architecture. At the foundation of the disconnect was the definition of the ENS. The IT personnel considered the ENS to be the technical components and configuration of those components designed and capable of delivering a message to a broad number of people as quickly as possible. The EM personnel considered the ENS to include the personnel receiving the message, the message structure, the user(s) sending the message, the technical components and configuration, and the public safety personnel responding to the incident. Furthermore, the EM personnel considered the required training and maintenance thereof a component to the overall ENS as well. This led to VTEM and Virginia Tech Network and Infrastructure Services (NI&S) collaborating on a multi-year effort to improve the overall system.

METHODOLOGY

The primary effort between the two departments was to define the ENS completely, followed by a thorough assessment of all components. The completion of these efforts resulted in a recognition of the power of this approach to proactively assess risk to system performance, and leverage that assessment to mitigate known risks, as resources and tolerance will allow. Initially, VTEM and NI&S developed a close working relationship through

the process of fully investigating any system disruptions identified because of consistent ENS testing. This relationship was paramount in developing a strategic path forward with full support to break down pre-conceived notions of the ENS, its definition, and performance, and build a foundation of shared understanding across the system. In 2017-2018, VTEM and NI&S, as well as other Virginia Tech partners, worked to map the ENS and build a greater understanding of various system components. By 2019, a standing work group was established, to include founding members from VTEM and NI&S, as well as, Virginia Tech Police Department and Virginia Tech Division of Operations IT. This work group (VT Alerts work group) jointly developed an approach to map, categorize, and assess the ENS with respect to performance through the lens of the Socio-Technical System (STS) theory (Hendrick and Kleiner, 2002). Figure 1 below provides a high-level generic system map as first conceived by the VT Alerts work group. This system map creates a shared understanding of the complete set of components (including the human elements), and provides for a rudimentary designation of task design represented by arrows marking a relational process.

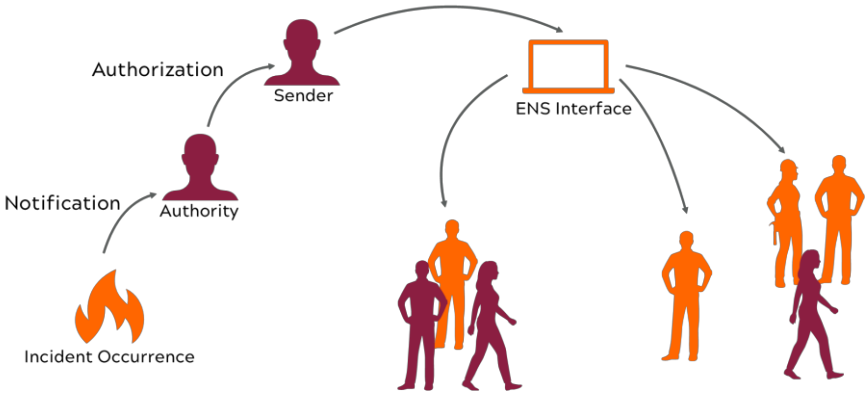

Figure 1. Original ENS Map

While this effort resulted in a common operating picture, the VT Alerts work group recognized the potential benefit of assessing the performance of this system as a proactive means to address system reliability. However, the ENS map falls short of providing an adequate construct by which to assess the ENS. Therefore, the work group sought a solution to frame the ENS in a manner supportive of developing performance metrics. The STS work system model (Figure 2) offered a framework, which the VT Alerts work group applied to the ENS map as a construct providing the means to assess the comprehensive system components. The VT Alerts work group then focused on identifying systemic components and the categories (e.g., Human subsystem, Technical subsystem, and Task Design) to which they belong. Figure 2 demonstrates the subsystems and general categories applied to each.

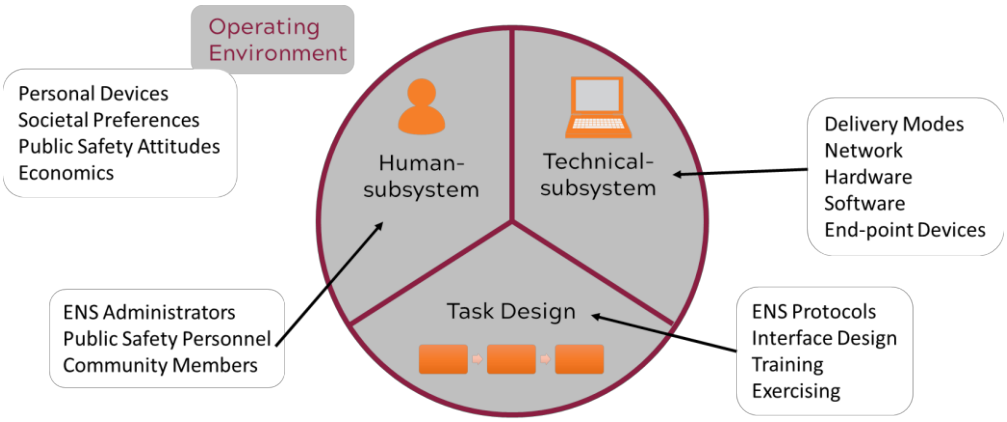

Figure 2. STS Applied to VT Alerts

This systematic evaluation provided firm boundaries that were advantageous to the VT Alerts work group in maintaining a shared understanding of the system, while performing a detailed evaluation involving a significant number of components and attributes. The VT Alerts work group recognized early in the process their responsibility to communicate their findings to Public Safety and University leadership. Through early organization and categorization, the VT Alerts work group benefited in the resulting ability to encapsulate more detailed and technical notions into higher-level categorical concepts focused on performance metrics at a system level.

During the process to identify, qualify, and quantify attributes related to subsystem components, the VT Alerts work group was challenged with ENS delivery modes. The delivery modes are defined as the technical components representing the function that transfers the intended message from the user interface to the targeted recipients. Examples of these delivery modes are text messages (SMS), telephonic calls (Pre-recorded or text-to-speech), and emails. Virginia Tech's ENS includes 14 potential delivery modes. The development of attributes to the delivery modes became complicated. The two primary challenges were achieving a consistency to the attributes, and tracking the number of attributes identified. The goal was to identify all the relevant attributes for supporting the development of delivery-mode performance metrics. The initial solution was to categorize the delivery-mode attributes. This allowed two-levels of attributes (categories vs. measurable attributes) and provided a mechanism to assign and track the means by which delivery-modes could be measured. The results of the delivery-mode attribute generation project are in Figure 3 below.

The VT Alerts work group then developed a more specific and technically oriented system map that included a more granular version of the ENS interface and technical subsystem using the delivery mode attributes. **Figure 4** is a simplified representation of this system map for readability. Each delivery mode of the full system map includes the attributes as shown in the call-out for the SMS delivery mode. After identifying the set of attributes for each channel (system component attributes and process connections), the resulting map provided an in-depth and detailed overview of the existing ENS.

Using the more detailed system map, the VT Alerts work group began an assessment of the overall system, with the goal of developing proactive approaches to maintaining a highly functioning, reliable ENS. The process for this assessment was more organic in nature, and the Conclusion section below provides both positive and negative outcomes identified to date.

CONCLUSION

This approach has resulted in a deeper understanding across a more complete group of stakeholders regarding the overall ENS. This process identified several areas for improvement, categorized below consistent within the applicable STS subsystems:

- Human Subsystem
  - Training of Administrators
    - The system includes multiple types of administrators, each with playing a role in the implementation of the ENS. This evaluation has identified inconsistencies in training, challenges in exercising the administrators, and potential solutions to address such challenges.
  - Exercise of system
    - The technical subsystem has historically been the focus of the system exercises. Conducted, at least twice daily, these exercises provide an excellent evaluation of the process from sender to end-point. The VT Alerts work group, using this process, has identified several means of conducting these exercises to improve decision-making prior to sending alerts.
  - Message Development
    - The current system protocols include message templates based on potential hazards, allowing the system administrator (sender) to use the most appropriate template to quickly develop a message. The initial effort resulted in the development of performance metrics that may offer an improved evaluation specific to message development. This work is ongoing.
  - Training and continued proficiency of Community Users
    - A unique aspect of this approach is to include those who receive the messages (alerts) as part of the system. This extends the performance metrics, and continuous improvement process to a much larger set of people. The advantage of this approach is two-fold: 1) the messaging and language are considered in terms of training potential, and 2) the systemic feedback loop includes those interpreting the message and the actions they take. Work to measure message interpretation and subsequent decision-making are ongoing.

- Technical Subsystem
    - Specific component upgrades
        - New/Upgraded Applications
            - Early results of this work included multiple additions of system component redundancies. Initial focus on hardware reduced mean time between failure, and multiple application upgrades.
        - Infrastructure redundancy
            - The system was designed with multiple redundancies, and has always been a focal point of the system. The VT Alerts work group is using this process to develop performance metrics for infrastructure evaluation in a structured and analytical manner.
    - Potential to develop delivery mode criteria and evaluation to expand notification in multiple dimensions.
        - Arguably, the most abstract results of the work thus far, are the recognition that performance metrics of the system offer the potential to structure the system by capability. In essence, channels (delivery modes) may be added or removed from the system based on a set of criteria designed to optimize delivery mode capabilities (reach, human factors, etc.).
- Task Design
    - Messaging templates
        - While closely related to the message development effort within the human subsystem, the messaging templates bring the developed messages to the technical subsystem (via delivery modes). This subsequent project is to marry the alert language to the appropriate delivery modes considering effectiveness of message interpretation, attention getting, and targeted audience. This work is ongoing,
    - ENS interface configuration
        - This project ties together the results of training administrators, message templates, system exercises, and continuous improvement. The intent is to optimize the ability of the sender to quickly identify the appropriate template, adjust language, maintain accuracy and brevity, and initiate the alert. The ENS interface configuration should also support decision-making. This work is ongoing.

The VT Alerts work group has also identified some challenges to this approach and are continuing to develop strategies to address moving forward. Particularly, there have been challenges to acquiring data to support the performance metrics desired. In several ways, the metrics of interest require sophisticated methods of data collection not yet implemented. Finally, the VT Alerts work group recognizes at times, work on the ENS has not adhered to the STS theory approach strictly enough to maintain consistency with the original goals. This requires a cultural change and setbacks have occurred.

In summary, this approach creates a foundation focusing programmatic efforts towards systemic improvement of the ENS. The benefits to VT Alerts have already been recognized, and the VT Alerts work group remains committed to this approach moving forward. The VT Alerts work group has also begun evaluating the potential for this approach, or similar, to evaluate and mitigate systemic risk associated with the ENS. The potential for developing a generic rubric to support the evaluation and assessment of any ENS, and methods to mitigate risk thereto appear promising with several other emergency management programs expressing interest in mimicking this approach.

REFERENCES

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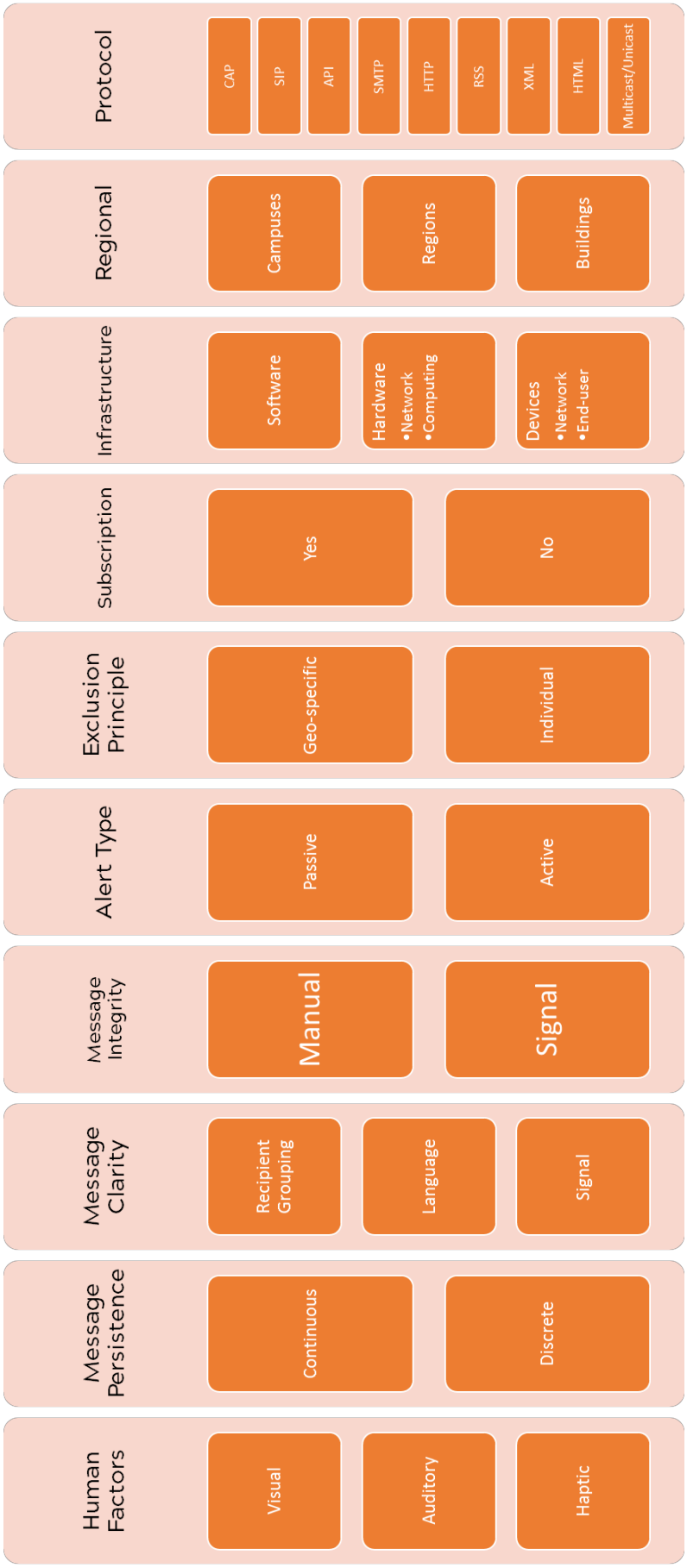

Figure 3. Categories and Measurable Attributes for System Delivery Modes

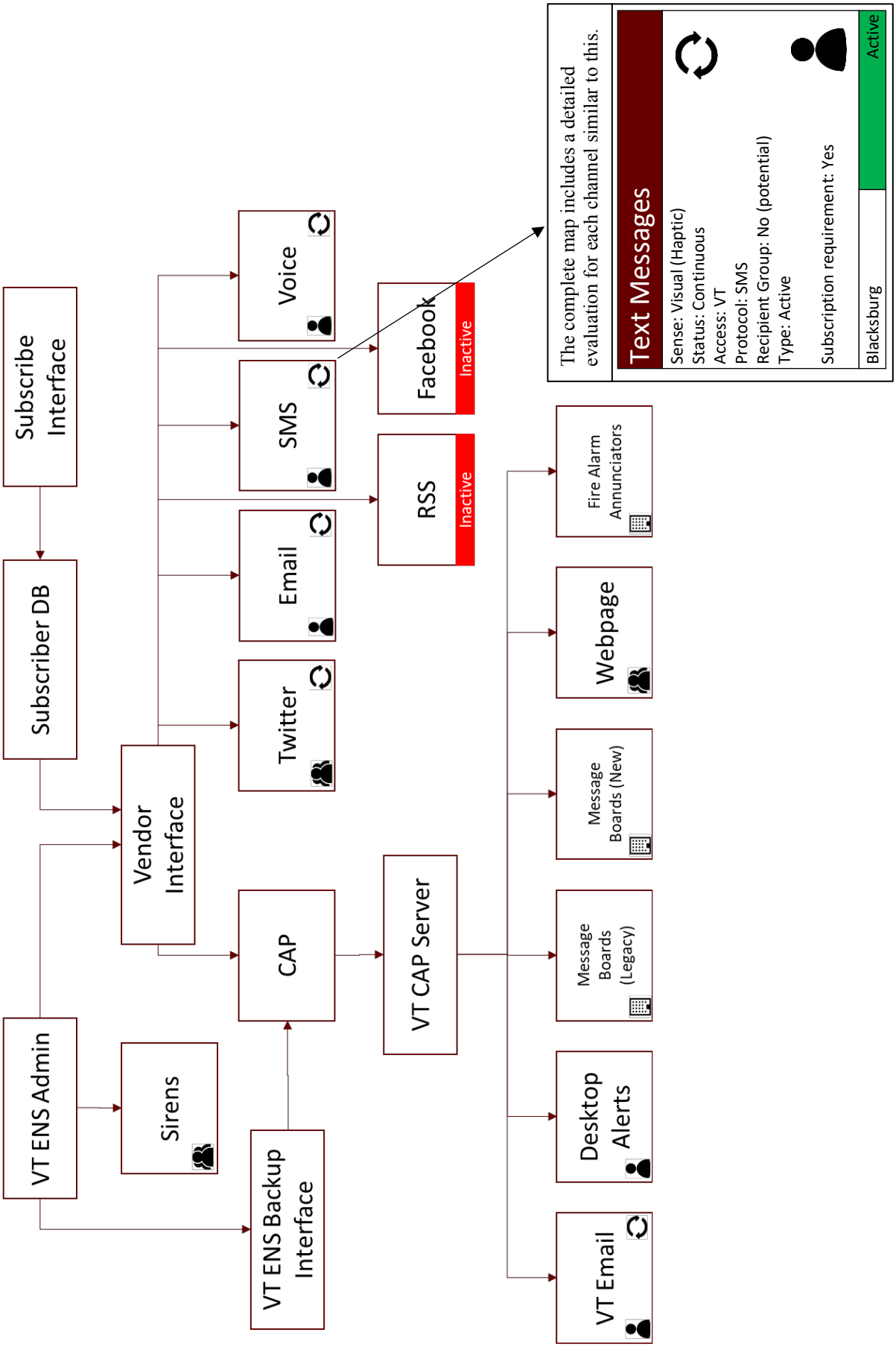

Figure 4. VT Alerts System Map – Simplified Representation