A Framework for Using Augmented Reality with Traditional Text Based Networking Tools

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ABSTRACT
In the present paper, we propose the use of Augmented Reality as a way of visualizing network data. This is done by a framework that we developed, called ARNet, for integrating Augmented Reality with traditional non-graphical network management tools. An evaluation of systems based on our framework demonstrates that Augmented Reality can help network managers to perform their tasks, and can be useful for training new network managers.

1. INTRODUCTION
Network Management deals with questions related to eventual faults of network resources, such as problems with devices and services, and unexpected interruption of communication, amongst other issues. The main challenges of this activity are to minimize the time spent with the diagnosis of such problems and to present appropriate solutions for them.

It is known that network administrators spend much time in the diagnosis stage, and that they can benefit from the existence of network tools [4]. In particular, graphical tools can significantly help managers to detect and understand network problems by taking advantage of Information Visualization techniques [2].

This work is a step further in the direction of developing effective and user-friendly network tools. It proposes the use of Augmented Reality (AR) [1] as a way of visualizing network data. The AR approach supplies an innovative kind of visualization that combines physical objects with real-time information about devices and network services. The specific goals of our research are: presenting a framework (ARNet), for extending text-based network management tools by combining them with AR and Information Visualization techniques; describing three prototype applications based on ARNet; and presenting a study that demonstrate the benefits of our approach.

2. THE ARNET FRAMEWORK
The ARNet framework is organized in four layers, as illustrated in Figure 1. In the lowest layer, we find the devices and the network services that will be monitored. In the layer above, that we call monitoring layer, we have the traditional network management tools and a new network management module which monitors items of the lower layer. The third layer is the visualization layer. It includes a visualization module, a video camera and a visualization device to see the extended image. Between the visualization and the monitoring layers, we have a sharing area that keeps dynamic information about the network elements. The user is located in the upper layer, controlling the video camera and observing the augmented image through the visualization device (a normal monitor or an eyeglasses device with LCD screens).

The functioning of the framework is as follows:

1. A central application reads a setup database with IP numbers and information about the fiducial marks assigned to them, and places this data into the shared area. Moreover, it sets the state of all devices and services listed in that area as “visually inactive”. Then, the application starts the network management module and the visualization module as two independent threads.

2. The visualization module uses the ARToolkit for continuously processing the image from the video camera. It searches for fiducial markers in the image and sets only the recognized items (devices and services) as “visually active” in the shared area. Additionally, this module constructs the augmented image of the visually active items, based on the network management information available in the shared area.

3. The network management module verifies in the shared area which items are marked as “visually active” and executes management commands (using non-graphical network management tools) to collect data about them. The resulting network data are filtered and saved again in the shared area.
The threads of the visualization and the network management modules execute uninterruptedly until the user stops the processing.

### 2.1 Applications

In order to test our framework, we developed three AR-based network applications that extend simple command-line network tools. They are:

- **ARNETVIS**: in this application, the user is physically remote to the devices and services that are being monitored. The user can perform remote monitoring by placing this marker on a desk or whiteboard, and pointing the video camera to it. An augmented visualization is then produced by showing the network data of all devices as a group of virtual icons. This data is collected by the network tool assigned to the marker. The user can get more detailed information about each device by touching its virtual icon with an "interaction stick", as well as, select another marker for visualizing different network data. Figure 2 shows an example of this model.

- **Whiteboard-ARNETVIS**: this application works like the model described above, where the user is remote to the devices and services that are being monitored. However, there can be many markers on the whiteboard, each one of them representing a single network device. The user can place the markers freely where he or she wants. A particular group of markers are reserved for selecting the network data to be displayed. This system can be seen in the Figure 3.

- **Mobile-ARNETVIS**: in this application, the user performs an on-site management of network devices by going to the room where they are located. The devices are previously labelled with markers, and the user has to carry a small computer set up for AR. By pointing a video camera to the physical devices (computers, hubs, switches, cables, etc.), labelled with the markers, up-to-date network information about them are immediately collected and combined with the video image to produce an augmented visualization. Figures 4 illustrate such on-site management.

The applications above are not mutually exclusive, since two or more copies of a marker can exist, one attached to its correspontent device and the others placed on the user’s desk.
The subjects were asked to perform some basic tasks, like locating which machines were initially up and down (all machines were started up later), locating them physically, identifying the computers that were up for a longer period of time and identifying the computers that might have higher risk of attack (due to the presence of more opened TCP/UDP ports).

They had to perform these tasks in four different ways: using the traditional shell commands, and the three applications described in the previous section. The tasks were video recorded and analyzed later. The subjects also had to answer a questionnaire about the advantages and disadvantages of using our systems.

4. CONCLUSIONS

The present research points to benefits in using AR for monitoring devices and visualizing network data. The framework is a new approach with great effectiveness power, because of the more natural association between physical devices and their network data (this is present in the on-site management model). Another benefit comes from the possibility of monitoring and analysis the status of remote devices and services by indirectly manipulating their markers. Note that the marks can not only be visualization tools, but also tools for interaction.

It is important to notice that our proposal is not to substitute the tools and traditional models of network management, but to complement them with an additional framework and associated tools. The appropriate public for such tools are lecturers and students in network administration courses, as well as beginner managers.

The main feedback points made by the subjects in the evaluation section were:

- They both commented that the AR based systems are more attractive and intuitive than the network management tools with shell commands.
- They said that even with tools based in graphical interfaces, real images augmented with network data in real time are visually more appealing.
- The managers agreed that tasks performed using shell commands demand more complex and longer training.

One administrator said that an experienced manager might get quicker results using shell commands. Nevertheless, he pointed out that more data was presented through AR simultaneously and in lesser time than using textual commands.

Regarding detection of network problems, all managers affirmed that the AR approaches where the user is remote are better for checking the state of several devices at the same time.

In the analysis of the recorded video, we also identified the following aspects:

- Each of the network administrators performed the proposed tasks in approximately one hour. In all cases, we observed that, during the use of the text-based tools, all users showed difficulties to enter the correct textual commands, as their syntax was not trivial.
- The Mobile-ARNETVIS was the highlight during the test phase. All administrators showed a visible inclination towards the kind of management approach it implements.
- The freedom to move the symbols around a white board and the possibility to write notes in the same space were also important highlights.
- All administrators did not have difficulties handling the symbols around the white board to get the information required for the proposed activities.

Despite the perceived benefits of using the applications, we found some limitations of the approach. They are mainly related to the ARToolkit’s features, like bad recognition of the symbols with fiducial marks and the limited amount of monitored elements with the marks.

The next step for the continuity of the research will be to implement SNMP (Simple Network Management Protocol) applications [3] using AR. Finally, we also intend to develop more compact and intuitive visualizations to present diverse kinds of data gathered by network management tools.

5. REFERENCES