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Development of a standalone and low-cost simulation switchboard

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Introduction

Newly qualified doctors must be able to recognize a deteriorating patient and escalate to senior colleagues for assistance, predominantly by telephoning for help [1]. We use simulation-based education to help medical students develop these skills. However, we identified that the existing telephone systems in our simulation centres were flawed, with critical practical and pedagogical consequences that we sought to overcome.

Previously, participants called a 'simulation switchboard' by using a telephone extension in the simulation room to dial a single number corresponding to an extension in the control room where faculty run the scenario. Unfortunately, immersed participants frequently dialled the standard number for the wider hospital's switchboard. More problematically, on numerous occasions, participants dialled the hospital's emergency number, 2222, attempting to request the resuscitation team. The actual resuscitation team were activated at least once, unnecessarily attending a real ward in the hospital. Colleagues in nearby centres described similar experiences.

In response, we trialled various standalone cordless handsets with an intercom feature. Unfortunately, this involved dialling an unusual key combination and participants frequently struggled, often requiring multiple attempts and assistance from embedded faculty. This simulation artefact reduced immersion and was commonly commented upon during debriefing, frequently detracting from discussion around the intended learning outcomes related to the phone calls. We sought to innovate a new telephone system that was separate from the hospital switchboard but functionally aligned with the real-world task of calling for help.

Innovation

A private branch exchange (PBX) is a telephone exchange or switching system required to route calls between telephone extensions [2]. Initially, we explored traditional landline PBX systems but these were prohibitively expensive, tending to cost upwards of several hundred pounds. Voice over Internet Protocol (VoIP) is an alternative technology which routes digital phone calls via the internet or a local network [3]. Most commercially available VoIP systems use cloud-based servers with annual subscription costs of approximately £150 and are reliant on an internet connection and specific compatible equipment.

Instead, we developed a standalone and low-cost system using the free and open-source software package, RasPBX hosted on Raspberry Pis (RPi), a range of

small, relatively low-cost single-board computers. RasPBX combines an RPi operating system with Asterisk, a software framework that acts as a virtual exchange for VoIP telephone systems, and FreePBX, an internet browser-based user interface [4].

As a prototype, we installed RasPBX on an RPi Model B+ which currently retails for under £25. This was connected to a standard home internet router, and a computer and smartphone running free VoIP software. We then successfully rolled out a live system to two simulation centres using fourth-generation RPis (currently retailing at £40); network switches (low-cost models available around £15) and cables; and commercially available VoIP phones (low-cost models available from £30). After installation, the system is disconnected from the internet. Figure 1 is a schematic of this system.

Using FreePBX's web interface, we created virtual extensions that all divert to a VoIP phone in the control room. This phone displays the number that the participant dialled to ascertain whom they intended to call.

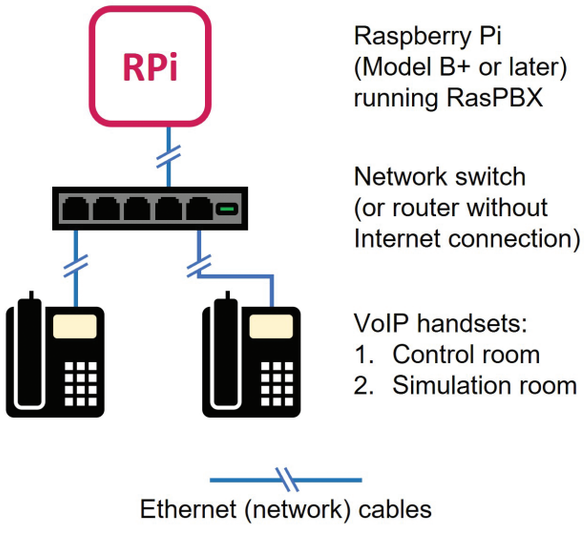
Finally, we exchanged the physical handset in the control room for a computer running free VoIP software with a headset. This allowed us to connect an audio feed of the faculty end of a call into the audiovisual system that allows learners not participating in a scenario to observe and, therefore, better contribute to debriefs. A simple method to achieve this uses Microsoft Windows' 'Listen to this device' function [5] and this setup is depicted in Figure 2.

Evaluation and outcomes

The standalone telephone system has been used for more than 500 simulation scenarios across our centres. It has allowed us to develop targeted simulation scenarios that allow medical students to rehearse and then discuss their decision-making around both a hierarchal approach to calling for help and activating the emergency team. This process now functionally reflects reality whilst avoiding both the potential patient-safety risks associated with inadvertent activations of real-world resources and the simulation artefact created by using an unfamiliar and unintuitive intercom system. Similarly, when the centre is used for postgraduate learning activities, participants can now dial the phone numbers that they would routinely use in real-world practice, increasing the fidelity of the simulations.

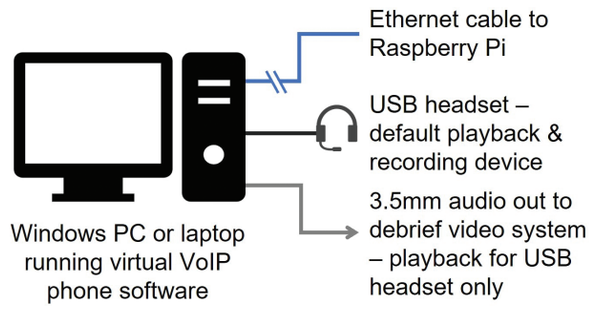
As an additional benefit, the new system allows learners observing the scenario from outside of the simulation room to clearly hear both sides of phone calls. This affords a shared experience that facilitates improved participation in discussions around a structured approach to asking for help or handover.

Figure 1: A schematic of the standalone telephone system.



Raspberry Pi is a trademark of Raspberry Pi Ltd.

Figure 2: A simple approach to integrating the telephone system with an existing audiovisual setup.



The computer running Microsoft Windows and VoIP software replaces the control room handset (1) in Figure 1.

What's next?

Similar setups can be implemented by other centres that wish to take advantage of a standalone telephone system. The publicly available instructions and support forums available for the free and open-source software detailed in this article make it viable for even those with limited technical expertise to develop their own system. Opting for basic models or refurbished or repurposed equipment has the potential to reduce costs even further.

Declarations

Authors' contributions

SC conceived the idea for the project, developed the prototype system and produced the first draft of the manuscript. AG used the prototype to develop the live systems, added additional features and critically revised the manuscript. Both authors approved the final version to be submitted.

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Availability of data and materials

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Ethics approval and consent to participate

None declared.

Competing interests

The authors declare no conflict of interest.

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