A new inclusive approach to remote microscopy

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Keywords: Standards, GRID, SuperSTEM

Remote microscopy has been seen as one of the mechanisms to improve access to highly specialised instruments. It can also play an important educational role in allowing schools to use electron microscopes in a routine manner [1]. Previously remote access has been implemented in one of two ways. The first approach has been to develop a solution that is specific to one microscope [2]. Although this has been successful, it results in multiple solutions being designed. The second approach has been to use proprietary software [3]. This too has been effective but relies on software not specifically designed for microscopy or designed for one manufacturer's products. Here we propose a preliminary standard under which, future, preferably open source, solutions can be developed. The idea of designing standards for remote access to highly specialised machines has been used before in other research fields. The astronomical telescope community have developed RTML [4] which allows several telescopes to be remotely controlled all using the same standard.

Issues to be considered are; security, defining (non-proprietary) data structures, communication, data transfer/bandwidth, and the modularity of the standard. Security, at its simplest, is the ability to authenticate the remote user and hence secure transfer of data over the network connection. Among many possible mechanisms, we propose using digital certificates, which are widely used and would make migration to the data GRID [5] easier.

Data structures should be defined so that storage is efficient, expandable and readily searchable. Using existing standards is preferable as long as they are sufficiently flexible to store all commonly used data types including, for example, spectrum images. There have been attempts to develop a data structure based on the .tiff format [6]. An assessment of this approach together with a survey of other candidate data structures will be presented.

For remote microscopy the main areas of communication that need to be addressed are the rules of interaction for human-to-human, human-to-machine and machine-to-machine communication. In the case of human-to-human communication we need to consider what type of interaction is best and balance this against the amount of bandwidth needed. The major concerns for human-to-machine and machine-to-machine communication are the integrity, the source, and the accuracy of the information received as well as the bandwidth needed. It is important to keep bandwidth within a range that is accessible by the majority, whilst not losing any functionality. One possible solution to this is the GRID as this guarantees a minimum bandwidth. Although the GRID offers solutions to several of the problems facing the development of a remote microscopy standard it is not possible to use the GRID as the sole solution, as many prospective users will not have access.

A modular standard is important to allow for reuse and mobility. A modular design would give the user the option of which components to use, whilst allowing the components to be implemented with relatively little modification. Modularity is also important in order to ensure backwards compatibility.

Figure one shows the schematic of a possible solution for remote microscopy at the SuperSTEM laboratory. Each of the components of the system is made up of smaller sub

components with the major sub-component being the access agent [7]. This would be responsible for the security of the system including the initial user identification, as well as the subsequent data transfer and encryption / decryption processes. The control agent, which can also be seen in some of the components, is used to control the remote microscope. The use of a standard would allow different systems to control the same microscope. For example in one instance the control agent may be a website which is dedicated to the specific instrument, whilst in another instance it may be generic software. This flexibility allows much greater access to remote microscopy.

Successful adoption of the proposed standard by the remote microscopy community will be reliant on an understanding of the adoption and usage environments, including barriers and catalysts to take-up. Such catalysts may include remote microscopy becoming an off the shelf application with less bespoke design. Initial consultations in the UK have been positive.

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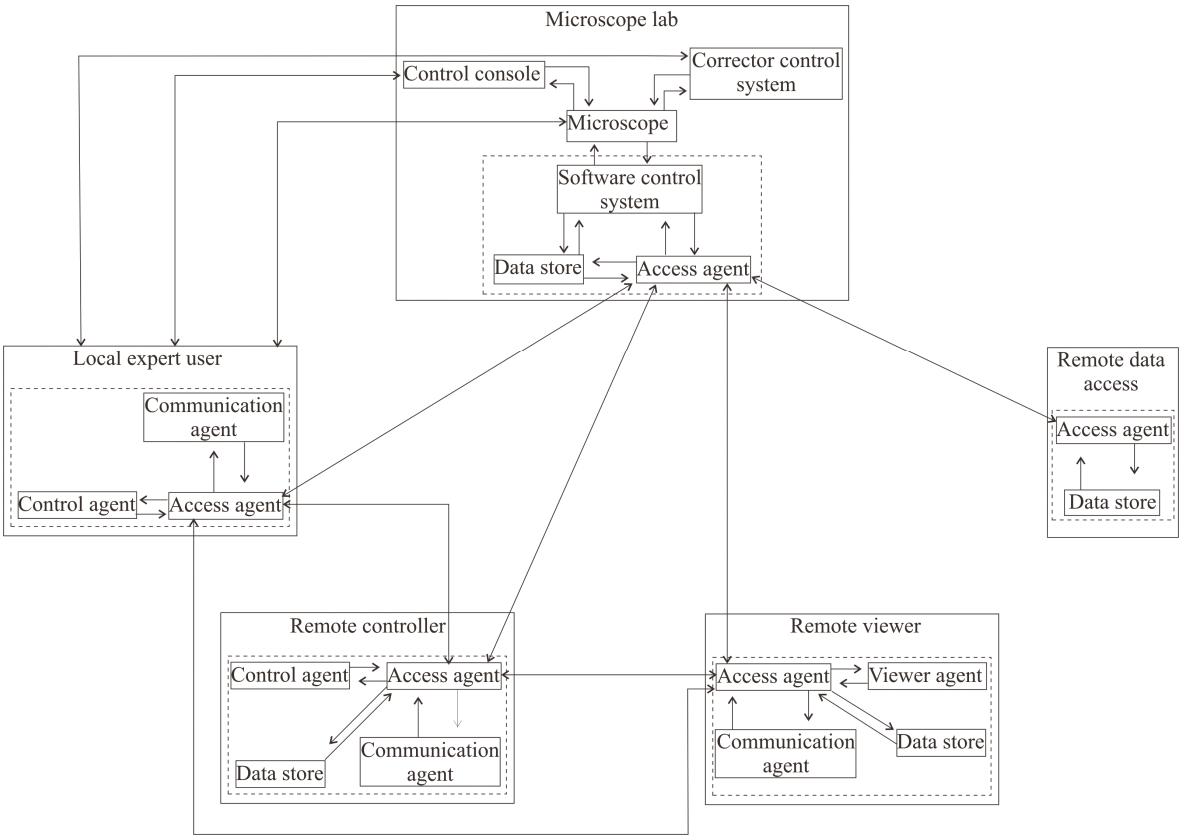

Figure 1. Plan of possible remote access system for the SuperSTEM showing three users, the local user, the remote controller user, and the remote viewer user who is only able to view the data being collected and has no control. Note fourth user is only accessing data.