

Introduction

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The nature of observational science, and astronomy in particular, is being transformed (as is so much of modern life) by the assimilation of new information technology. A central theme throughout the history of astronomy has been the mapping of the Universe to greater and greater distances and, in the last half century, over broader and broader ranges of the electromagnetic spectrum. As we have conducted more comprehensive surveys, it has become clear that there are rapid changes in the distant Universe with durations measured in days or even seconds, and that those ephemeral changes provide important clues about the nature and evolution of our Universe. One spectacular example was the discovery of a flash of light, associated with a gamma-ray burst at a distance of 7.5 Billion light years ($z=0.94$), that for 5 seconds was bright enough to be visible to the naked eye. However, that flash—the most luminous ever recorded by humankind—was not discovered by a human observer. The discovery and initial real-time follow-up of this cosmic explosion, which marked the collapse of one of the very first massive stars in the Universe and announced the formation of a black hole, was conducted entirely by autonomous robotic instruments communicating through the internet.

The scientific potential of this Time Domain Astronomy has placed it high in US astronomical community priorities for the next decade and helped give the Large Synoptic Survey Telescope (LSST) the top ranking for new ground-based programs. But the key unsolved problem for exploring fast astrophysical transients in a variability survey with the scope of LSST is mining the torrent of data—which for LSST will be something like a 3.2 Giga-pixel image every 10 seconds—to recognize important variations in a scene full of normal variations and command follow-up observations in real time. With its predicted discovery of thousands of transients every night, the LSST threatens to drown us in a “flood of data”, conduct denial of service attacks on our robotic follow-up telescopes, and in the end leave us thirsty for knowledge. For fast transients this challenge is particularly acute because humans do not have the attention span, memory, or reaction time required to monitor the huge volumes of data, recognize the important variations, and promptly command follow-up observations.

Mastering the challenges that massive variability surveys like the LSST project pose for rapid-response astronomy requires the development of new infrastructure. The VOEvent communication standards are an important foundation block of the new infrastructure. Meetings that enabled VOEvent development also helped foster discussion and ideas about how the next generation infrastructure could be built using machine learning, event brokers, and other new information technology techniques. This book came to be as a response to the need to both document and disseminate some of the evolving standards and to articulate some of those new ideas.