Advanced Mobile Systems Initiative

Software Engineering Institute
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Access to digital communication and computation capabilities can greatly increase the effectiveness of people in austere environments—soldiers in battle, troops engaged in humanitarian assistance, or first responders in a disaster area. Digital resources can enhance the ability of such "edge users" to fully understand the situations in which they operate and to act with confidence. Remote sensor data, for example, can improve surveillance or search and rescue, and enhanced computational capabilities can support tasks such as facial recognition and language translation. Yet in these austere environments, digital resources are often limited, intermittent, or nonexistent. Even power may be unavailable.

The SEI Advanced Mobile Systems (AMS) initiative develops concepts and prototypes to support the mobile-communication and mobile-computing needs of edge users. AMS develops and applies the latest mobile technologies to help users make timely decisions or take timely action by opportunistically leveraging computational resources and data that are available in the edge environment to increase situational awareness. In collaboration with researchers at Carnegie Mellon University and other organizations, AMS has developed a number of capabilities that interact to meet edge users' needs. AMS's world-class developers are skilled in mobile communications, rapid prototyping, Android app development, tactical cloudlets, and real-time data analysis. They apply these skills to identify, analyze, and craft solutions to the challenges that edge users face.

The repertoire of AMS technologies is constantly expanding, and can be readily directed to solve the immediate and pressing problems of AMS clients.

Technologies listed below are examples of the concept-development and prototyping capabilities of AMS:

1. Creation of a digital infrastructure with the use of tactical cloudlets (Digital Infrastructure Creation with Tactical Cloudlets, p. 2)
2. Creation of mobile applications to provide shared and role-specific context awareness for groups in tactical settings (Group-Context-Aware Data and Resource Sharing, p. 3)
3. Mining of data streams for intelligence (Mining Data Streams for Intelligence, p. 4)
4. Creation of groups of collaborating autonomous devices easily controllable by a single person (Group Autonomy for Mobile Systems, p. 5)
5. Creation of customized mashups that enable users to view integrated data from multiple sources on a single mobile display (Rapid Integration, Aggregation Filtering, and Analysis of Data for Mobile Users, p. 6)

These technologies work together to bring both information and computational capability to edge users, as shown in Figure 1 and discussed below.

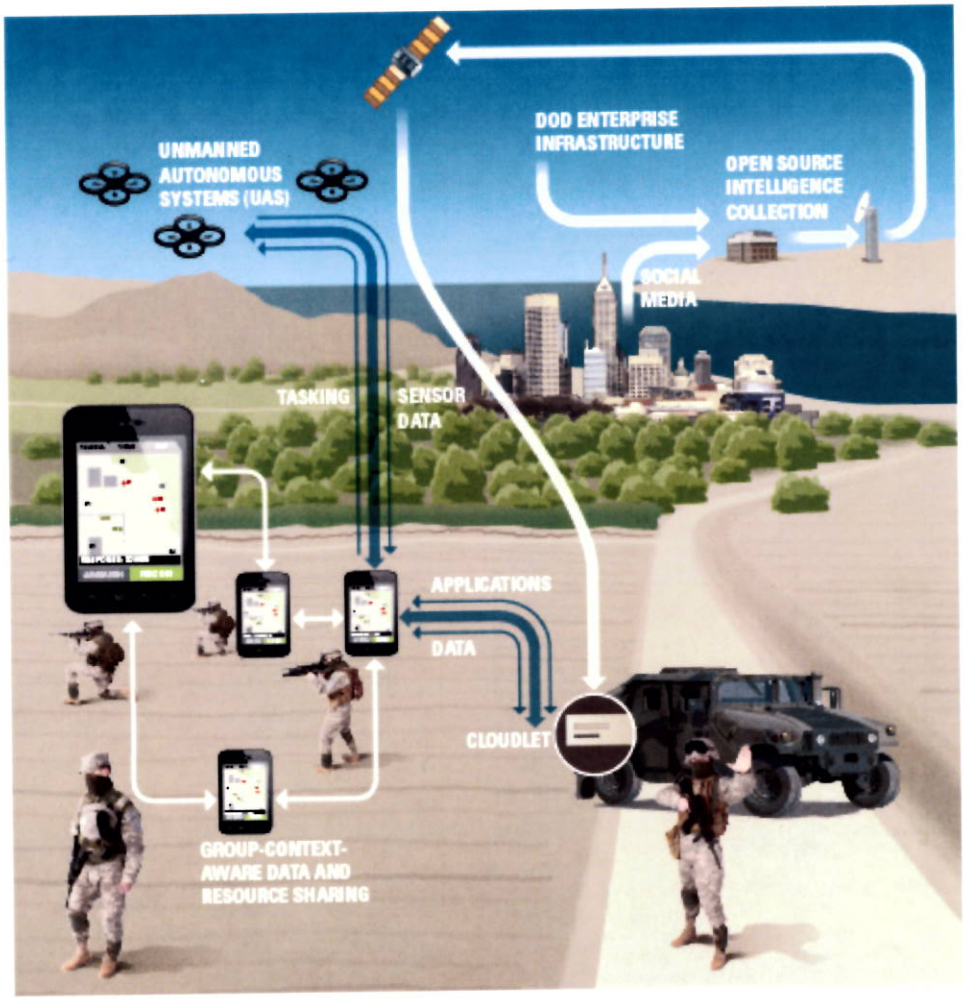

Figure 1: AMS Application Domain

Digital Infrastructure Creation with Tactical Cloudlets

Today's edge users are increasingly equipped with mobile computing and communications technology that enables them to share data and access complex applications such as facial recognition and language translation. Since computational power and battery power are limited, these mobile devices typically reach back to external resources such as cloud resources or data centers to support the needed capabilities. But in an austere environment such as the aftermath of a tsunami, or a hostile environment such as the center of an insurrection, access to these remote resources may be compromised, degraded, or disabled, severely limiting access to the needed capabilities.

The deployment of a local cloudlet solves this problem. A cloudlet is a discoverable mobile cloud resource that supports edge-user mobile devices.

The mobile devices are just one network hop from the cloudlet; hence they have adequate connectivity to enable devices to offload computational tasks to the cloudlet and share data and applications.

The cloudlets are pre-loaded with the applications and data likely to be needed by the edge users. If an edge user wants to access an application or a data source not pre-loaded on the cloudlet, it attempts to acquire the needed resource from the enterprise cloud or the mobile device itself. The cloudlets attempt to maintain communication with the central core to ensure that needed data and applications are current. However, when that connectivity is lost or degraded, the cloudlet still supports the mobile devices using the most current information available. The cloudlets use virtualization technology to execute legacy applications in their native environments, providing access to them via mobile apps without having to port them to the mobile devices.

Cloudlets can also communicate with each other, providing redundancy and continuity of operations for edge users in hostile and otherwise constrained environments.

Forward-deployed, discoverable, virtual-machine-based cloudlets can be hosted on vehicles or other platforms to provide

- infrastructure to offload computation
- forward data-staging for a mission
- data filtering to remove unnecessary data from streams intended for dismounted users
- collection points for data heading for enterprise repositories

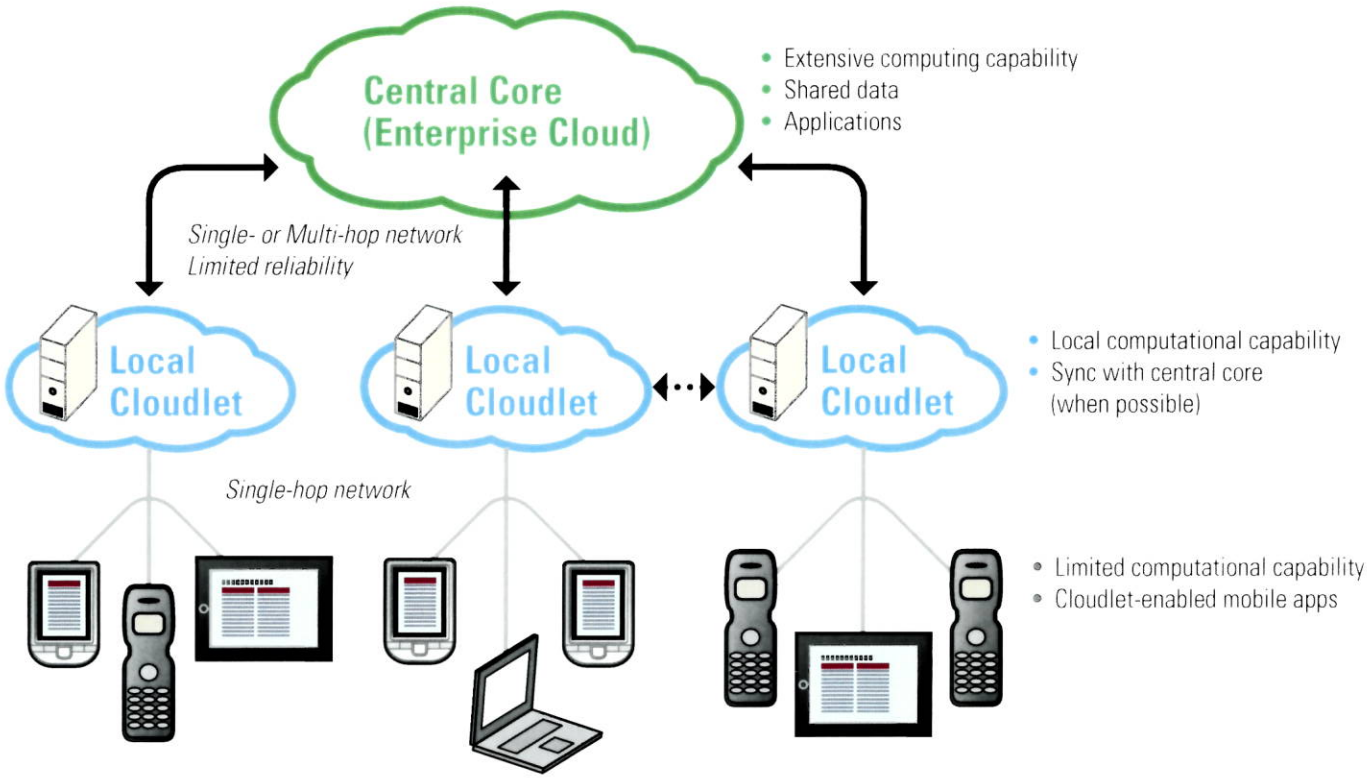

Figure 2: Digital Infrastructure Through Cloudlets

Group-Context-Aware Data and Resource Sharing

Teams of personnel operating in edge environments are often overloaded and unable to extract meaningful, useful information from the flood of data available to them. They also may not always be aware of potentially helpful information sources, or even the location and status of team members. What's more, in constrained environments, computation capabilities may be limited to what can be carried (such as a mobile phone or tablet), mobile bandwidth is at a premium, and battery power must be conserved because opportunities to recharge may be scarce. These challenges make it difficult for edge users to collect and distribute information to maintain situational awareness and to gain access to resources that are critical to achieving their defined missions.

AMS builds mobile applications that operate with knowledge of the individual user's and the team's context to get the right information to the right people at the right time in an efficient way. For example, a mobile app that is aware of nearby team members can collaborate with apps carried by those users to eliminate sending and display of redundant or unnecessary data, and thereby conserve both battery power and bandwidth. The app can also facilitate coordination during search and rescue operations by detecting nearby searchers and displaying their locations on a map. Context-aware apps can also provide feedback data on individual users. Many mobile devices contain position sensors, movement sensors, light sensors, and proximity sensors. The app can monitor these sensors and infer the activities of the user—for example, whether the user is running or stationary—and provide valuable status information back to the team. These features of group-context-aware apps can reduce the cognitive load on individuals and on the team by providing targeted information, and help coordinate group activities to improve the accuracy and speed with which the team completes its tasks.

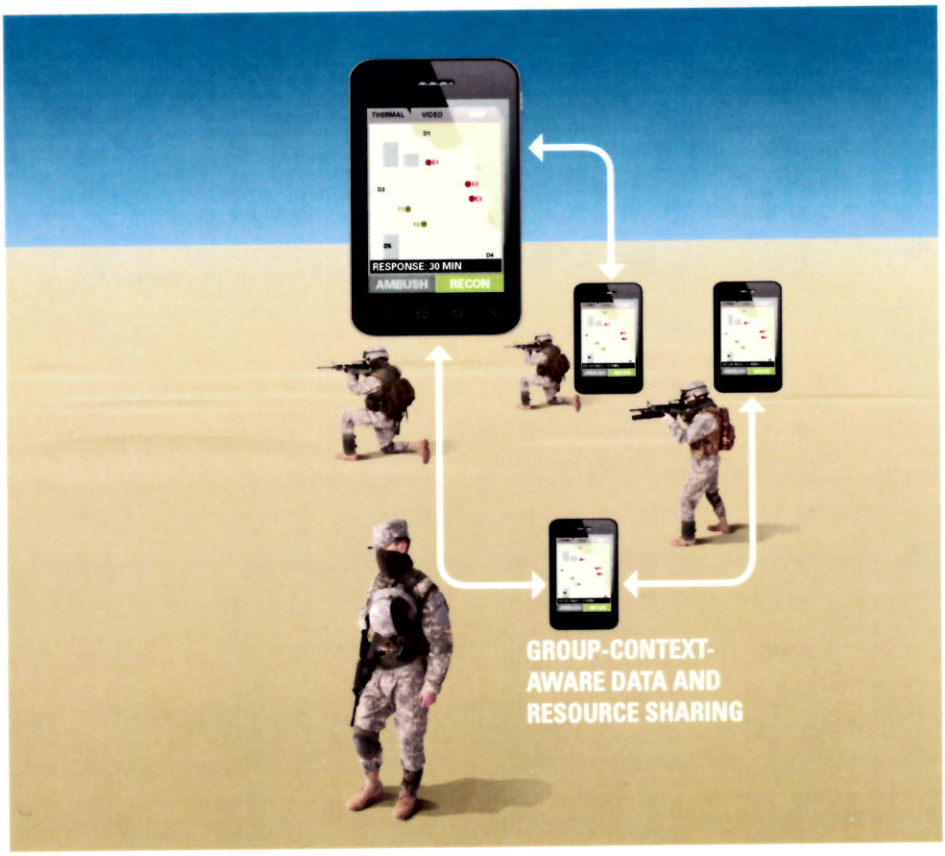

Figure 3: Group-Context-Aware Data and Resource Sharing

Mining Data Streams for Intelligence

Everyone today is surrounded by streams of data. Social media is ubiquitous, with 58 million tweets and 10 billion Facebook messages daily. Buried within this avalanche of publicly available data is a wealth of information. Under normal circumstances, data within these streams are unfocused, without any dominant trend or pattern. However, when a significant event occurs, new trends in publicly available data emerge. AMS has developed techniques to mine these data streams, identify these trends quickly, and extract information to increase situational awareness in times of crisis. This capability can be of value to the military, law enforcement, and first responders. For example,

- Military patrols in hostile environments can use this capability to gain insight into current events and also to gauge public sentiment. For example, if an insurgent attack is initiated, citizens in the vicinity may begin tweeting and posting. With the AMS capability, friendly forces can extract relevant information from whatever social-media data streams are available that may help them localize the attack, track the insurgents, assess the current situation, and understand the public sentiment regarding the attack.
- When an incident—a fight, gunfire, explosion, or any event that endangers public safety—occurs in a public venue such as a sports event, a concert, or a parade, people exposed to the incident may use their mobile devices to tweet or post it. With the AMS capability, law enforcement personnel can mine social-media data streams to identify the location of the incident, assess the situation, and understand public perceptions, thereby improving and accelerating their response.
- During a natural disaster (such as a hurricane, earthquake, or wildfire), citizens affected by the event may use their mobile devices to tweet or post about it. With the AMS capability, first responders can monitor social-media data streams to gain rapid, unofficial knowledge regarding the event, collecting information such as the geographic extent, the severity of impact, the responses of other organizations, and the public response to the event. This information can be used to plan better and faster responses.

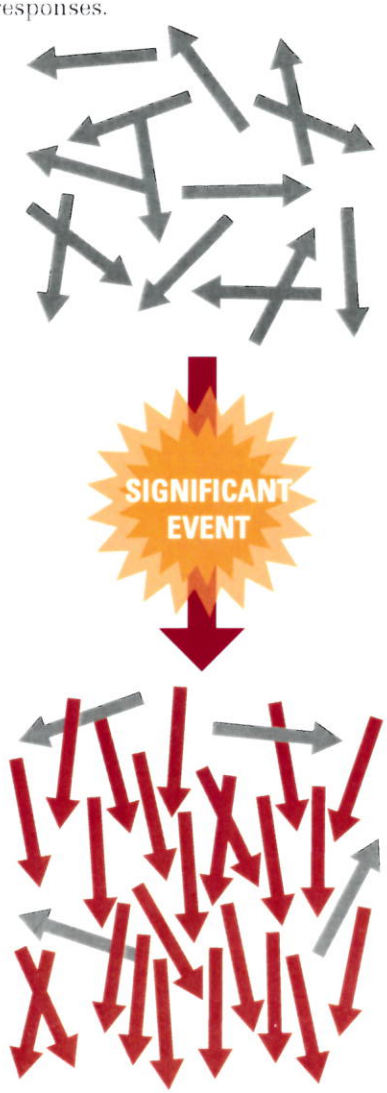

Figure 4: Social Media Response to Events

Group Autonomy for Mobile Systems

Superior information improves the ability of a soldier on the battlefield or a first responder in a disaster area to complete their missions. Recent advances in the commercialization of remote video, acoustic, motion, infrared, and electromagnetic sensors offer the opportunity to improve information gathering, dissemination, and contextual reasoning of small squads in hostile, challenging environments at low costs. Unmanned aerial vehicles (UAVs) provide the ability to place those sensors where they are most useful. But employing a set of sensors, a UAV, or a group of UAVs can demand more time and concentration than an edge user can spare. Autonomous UAVs and other unmanned autonomous systems (UASs) provide solutions to this dilemma. They can be pre-programmed with capabilities to execute a variety of missions such as reconnaissance, search, or communications bridging. In the field, an edge user can easily define the mission for the UAS and deploy it with little time and effort.

For example, a swarm of small UASs equipped with visual and infrared sensors can be used to search a debris field for survivors. The user can define the search region simply by drawing a polygon on a map on his or her mobile device. Given this mission, thermal-sensor-equipped unmanned UASs will automatically partition areas of the search region and collaboratively plan and execute a systematic search, showing possible survivors on the map as thermal hits.

Similarly for a reconnaissance mission, the UASs can again scan a designated area, but this time using a search pattern to make their movements unpredictable, thereby thwarting enemy attempts to destroy them.

UASs may also be used to enhance communications networks, extending network range by "bridging" between devices, operators, or other UASs.

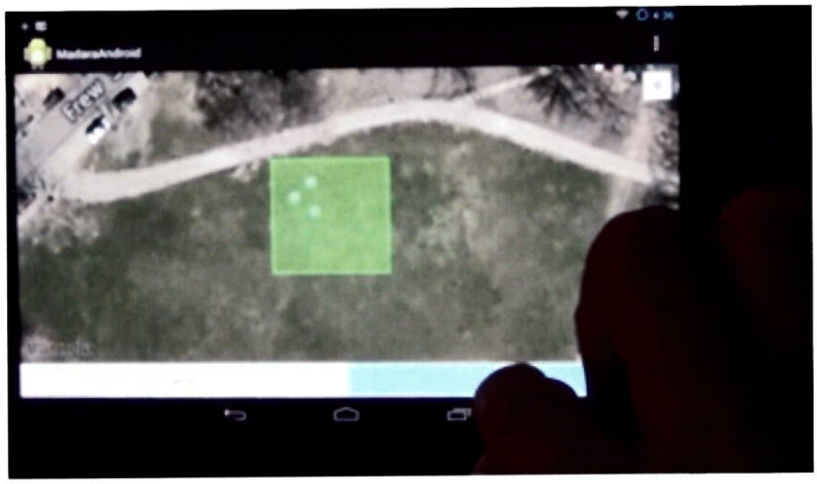

Figure 5: UAS Search Area Definition on a Mobile Device

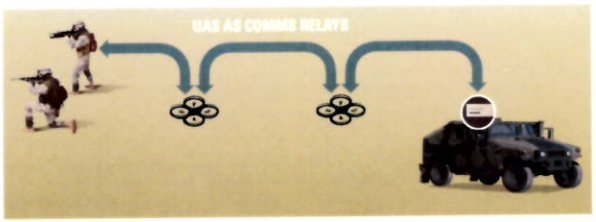

Figure 6: Network Bridging with UASs

Rapid Integration, Aggregation Filtering, and Analysis of Data for Mobile Users

Through their mobile devices, edge users may have access to numerous data sources from the military (both U.S. and allied), other government agencies, and non-government agencies, as well as from public data. If the data needed to support a mission is not available from just a single source, the ability to integrate data from multiple sources can improve the quality of the information. AMS has developed the capability for edge users to rapidly integrate, aggregate, filter, and analyze data from multiple sources on a single mobile display.

For example, after Hurricane Sandy, first responders in New York City could have used the application to query Twitter streams for SOS messages, filtering the incoming data to contain only SOS messages from New York City. This data could then have been combined with Foursquare data to give them information about all local businesses and establishments around them. Image data from Flickr could have been added to give them live, incoming pictures of flood damage, road closures, etc.

With the AMS capability, all of this data could have been displayed on one screen and quickly analyzed by the first responders to give them better awareness of their surroundings and to help them find those in need.

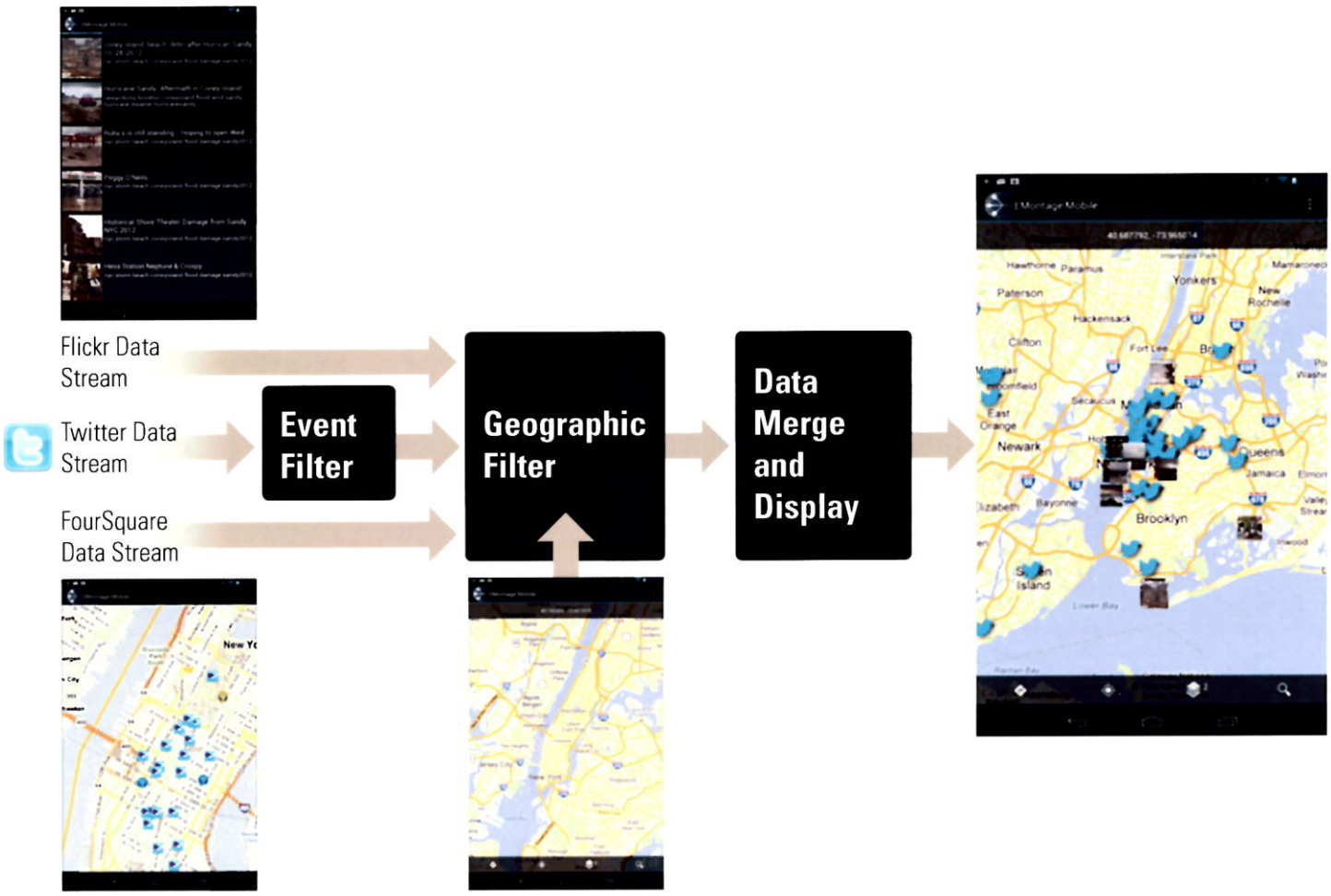

Figure 7: User-Configured Situational Awareness Mashups

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The technologies described here are only examples of what AMS can do. AMS's staff, skilled in mobile communications, rapid prototyping, Android app development, tactical cloudlets, and big-data analysis, can address your most critical mobile computing and communications needs. Our experts are ready to help you with whatever mobile technology challenges you may face.

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