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APPLICATIONS OF WIRELESS SENSOR NETWORKS IN BATTLEFIELD SURVEILLANCE

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Abstract: Wireless sensor networks (WSN), sometimes called wireless sensor and actuator networks (WSAN), are spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. The prime idea of FCS concept is to support the soldier with real time situational awareness and joint operability among forces to complete a mission successfully with low mortality rate. This system allows the soldier to see first, understand first and act decisively. Basic work done behind the screen is fusing data collected from different reconnaissance vehicle, unattended ground sensors, unmanned aerial vehicles and live assets. System of system common operating environment supports the system. SOSCOE provides reusable software architecture for platform and battle command application via low bandwidth Adhoc network. It uses TINEX workflow engine which minimizes traffic and allows different software to execute flexibly. Since, most of the system operates in remote environment with battery support, power consumption is a serious issue. System with many nodal points has to be encrypted strictly to prevent the network from attacks (simply hacking).
Keywords Battlefield, future combat system, system of systems, advanced trauma management, multifunctional aerial system, wireless sensor network, cluster integration, distributed clustering.

I. INTRODUCTION

A WSN node contains several technical components. These include the radio, battery, microcontroller, analog circuit, and sensor interface. When using WSN radio technology, you must make important trade-offs. In battery-powered systems, higher radio data rates and more frequent radio use consume more power. Often three years of battery life is a requirement, so many of the WSN systems today are based on ZigBee due to its low-power consumption. Because battery life and power management technology are constantly evolving and because of the available IEEE 802.11 bandwidth, Wi-Fi is an interesting technology. The second technology consideration for WSN systems is the battery. In addition to long life requirements, you must consider the size and weight of batteries as well as international standards for shipping batteries and battery availability. The low cost and wide availability of carbon zinc and alkaline batteries make them a common choice. To extend battery life, a WSN node periodically wakes up and transmits data by powering on the radio and then powering it back off to conserve energy. WSN radio technology must efficiently transmit a signal and allow the system to go back to sleep with minimal power use. This means the processor involved must also be able to wake, power up, and return to sleep mode efficiently. Microprocessor trends for WSNs include reducing power consumption while maintaining or increasing processor speed. Much like your radio choice, the power consumption and processing speed trade-off is a key concern when selecting a processor for WSNs. This makes the x86 architecture a difficult option for battery-powered devices. At the heart of the FCS, BCT is the network which will allow every FCS system from unmanned vehicles to precision weapons to share the information and work together. The network will offer decision-making not just at the brigade level, but all the way down to the battalion and company levels. The FCS allows the army to achieve greater situational awareness, improved survivability, lethality, efficiency and joint operability. On today’s battlefield, the availability of real-time information is vital for success. FCS technology will allow the soldiers to see first and understand first: from a position far away. Systems such as the Unattended Ground Sensor (UGS), Unmanned Ground Vehicles (UGVs) and Unmanned Aerial Vehicles (UAVs) will provide information about the enemy’s position in individual buildings and neighborhoods, as well as over the bunkers. Wireless sensors can be used in case of unattended war environments. This information will be fed into the network and immediately shared with brigade, battalion and company commanders, even to the platoon leaders. This networked surveillance increases the reliability of information and reduces tactical risk to the soldiers. In short, FCS provides enhanced situational awareness. On today’s battlefield, precision weapons are necessary to defeat enemies who are often mixed with civilian populations or hidden in restrictive terrain such as mountainous regions. FCS systems such as the Mounted Combat System (MCS), Non-Line of Sight-Cannon (NLOS-C) and Non-Line of Sight-Mortar (NLOS-M) [2] combined with FCS’s unmanned systems and the soldiers, provide the ability to destroy enemy and increases the ability to identify targets and to engage with precision munitions that reduce the risk of collateral damage. On today’s battlefield, soldiers in complex environments are at risk within vehicles, due to the enemy’s use of Improvised Explosive Devices (IEDs), Rocket-Propelled Grenades (RPGs) and Anti-Tank Missiles. As the soldiers move into complex terrain (urban areas) where the enemy is well hidden and traditional fighting vehicles are largely ineffective. FCS reduces that risk by using unmanned vehicles such as the Armed Robotic Vehicle (ARV), Small Unmanned Ground Vehicle (SUGV) and Multifunctional Utility/Logistics and Equipment Vehicle (MULE) to locate and engage the enemy, identify toxic chemicals, destroy tanks and disable the land mines [4]. FCS manned vehicles are agile and carry an advanced hit avoidance technologies such as active protection systems (APS) which allow the soldiers to stay protected longer, which reduces their risks before delivering them close to the fight. In short, FCS increases survivability as well as lethality. On today's battlefield, it is more important to maximize the fighting capacity of the force. The FCS (BCT) features smaller, lighter vehicles which quickly transport more combat power to where it's needed. In addition, FCS vehicles will require much less fuel, reducing the number of refueling vehicles. By building many of its systems on a common chassis, the number of mechanics and spares will be reduced. In addition, reduced support requirements mean fewer convoys. Threats from IEDs will be minimized by FCS's sensors and robots. In summary, FCS increases efficiency and reduces the Army's logistics footprint, resulting in fewer support soldiers and vehicles, thus saving lives and money. Because FCS is a system of systems, the whole is more than the sum of its parts. By interconnecting the capabilities of 18 cutting-edge systems with a state-of-the-art network and the unmatched abilities of the soldier, FCS will allow the Army to find, fight and finish the enemy on the 21st century, irregular battlefield. These systems are basically classified in to the following on the basis of their operation and functionalities: Manned ground vehicles, unmanned ground vehicles, unmanned aerial vehicles and unattended systems. In recent unattended environments, Wireless Sensor Networks (WSN) with multifunctional sensing capabilities can be employed on both vehicles and the soldiers to offer better outcome [7].

II. EXISTING SYSTEMS AND FEATURES

The Mounted Combat System (MCS) provides Line-of-Sight (LOS) and Beyond-Line-of-Sight (BLOS) offensive firepower capability allowing BCTs to engage close with and destroy enemy forces. The mounted combat system provides precision fires at a rapid rate to destroy multiple targets at standoff ranges quickly to complement the fires of other systems in the BCT. It is highly mobile and can easily maneuver over rough terrains. It is capable of providing direct support to the infantry in an assault by defeating bunkers, breaching walls and also by providing cover fire whenever necessary. The MCS also provides BLOS fires to destroy the point targets using the integrated sensor network. This capability enhances lethality and also increases the options available to the BCT commander for the destruction of point targets through the integrated fires network. MCS shares a common mobility platform with the other Manned Ground Vehicles of FCS [11]. The Infantry Carrier Vehicle (ICV) consists of four platform versions: a Company Commander; a Platoon Leader; a Rifle Squad and a Weapons Squad. All infantry carry vehicles looks alike to prevent particular vehicle from targeting. The ICV effectively employs weapon systems, rapidly maneuver during fallback, night operations, all weather and limited visibility periods. The ICV carries most of equipment freeing the individual soldier to focus on the mission. The ICV can shoot, communicate, detect threats and protect crew/critical components on the move and almost under all retains. Constant data transfer with other components of the BCT permits constant update of the common operational picture and rapid identification of targets with updated situational awareness. The Non-Line of Sight-Cannon (NLOS-C) (figure 1) is an indirect fire support component of the System of Systems (SoS) of the FCS (BCT) [5]. NLOS-C is more significant to provide networked, extended-range, responsive and sustained precision attack of point and area targets in support of the FCS [6]. NLOS-C provides close support and destructive fires for tactical standoff engagement during both offensive and defensive operations in line-of-sight and beyond-line-of-sight. The NLOS-C is a self propelled howitzer with a two man crew. Advanced Crew Served Weapon (ACSW) as its secondary armament and incorporates a suite of protection measures to enhance crew and platform survivability. The NLOS-C will be deployable worldwide and can operate in a wide range of ordinary environmental conditions. The cannon can move rapidly, stop quickly and deliver lethal fire on target in a very short time. The NLOS Cannon has a multiple round simultaneous impact (MRSI) capability. The cannon, like all Manned Ground Vehicle (MGV) can rearm and refuel quickly. Its system weight makes it quickly deployable, fully automated handling, loading and firing is the state of the art modern engineering work piece. The NLOS-C adoptability and sustainability with fast response [1], lethality, survivability, agility and versatility are quite modern features. The Non-Line of Sight-Mortar (NLOS-M) is the short-to-mid-range indirect fire support component of the System of Systems (SoS) of the FCS (BCT). It fires a suite of 120mm munitions that also include special purpose precision guided munitions such as Precision Guided Mortar Munitions. NLOS-M provides close support and destructive fires for tactical standoff engagement during both offensive and defensive operations.

Figure 1: Non-Line of Sight Cannon (NLOS-C)

The Reconnaissance and Surveillance Vehicle (RSV) consist of a set of advanced sensors technology which can able to detect, locate, track, classify and automatically identify targets from for-beyond ranges under all climatic conditions: day or night [14,15]. It includes a set of roof-mounted, long-range electro-optic infrared sensor, emitter mapping sensor for radio frequency intercept and direction finding, remote chemical detection and a multifunction RF sensor. RSV also conducts automatic target detection, target recognition and level one sensor fusion. To further increase troop capabilities, the RSV is equipped with Unattended Ground Sensors (UGS), a Small Unmanned Ground Vehicle (SUGV) with other payloads and two unmanned aerial vehicles (UAVs). WSNs recently started replacing these sensors, for their advanced and undetectable presence in unattended environments [3]. The Command and Control Vehicle (C2V) is part of manned ground vehicles and is the hub of battlefield command and control. The C2V platform provides the commander the necessary information to lead the team towards success. It is capable of joint command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR). The C2V provides commanders with the ability to command and control on the move. C2Vs contains the interfaces that allow commanders and superior staff to gain access to the Battle command mission applications including: mission planning and preparation, situation understanding, battle command and mission execution and war fighter-machine interface. These applications enable commanders and their staff to perform tasks such as fusing friendly, enemy, civilian, weather/terrain situations and distributing this information via a common operating picture. Commanders also utilize the C2V's integrated C4ISR suite to receive, analyze and transmit tactical information. The C2V can also deploy wireless sensor based unmanned and manned aerial vehicles to enhance situational awareness. The Medical Vehicle is designed to provide advanced trauma life support within hour to critically injured soldiers. The Medical Vehicle serves as the primary emergency treatment system within the Brigade Combat Team and has two mission modules: Evacuation and Treatment. The Medical Vehicle-Evacuation (MV-E) vehicle allows trauma specialists, to be closer to the casualty's point-of-injury and is used for casualty evacuation. The Medical Vehicle -Treatment (MV-T) vehicle enhances the ability to provide Advanced Trauma Management (ATM)/Advanced Trauma Life Support (ATLS) treatments and procedures forward for more rapid casualty support and clearance of the battle space. Both modules will be capable of conducting medical procedures and treatments using installed networked telemedicine interfaces, Medical Communications for Combat Casualty Care (MC4) and the Theater Medical Information Program (TMIP). The FRMV is the recovery and maintenance system for employment within both the Brigade Combat Team (BCT)/ divisions and contributes to sustaining and generating combat power to the Future Force structure. Each BCT will have a small number of 2-3 man Combat Repair Teams within the Brigade Support Battalion (BSB) to perform field maintenance requirements. The capabilities of the FRMV include in-depth Battle Damage Assessment Repair (BDAR) and it limits the recovery operations. The Armed Robotic Vehicle (ARV) (figure 2) is an unmanned 9.5 ton 6x6 Hybrid Electric Drive (HED) vehicle and comes in two variants: the Assault variant and the Reconnaissance, Surveillance and Target Acquisition (RSTA) variant. The two variants share a common chassis. The Assault variant will support the troop in the assault with direct fire of anti-tank weapons providing LOS/BLOS targeting. The RSTA version will remotely provide reconnaissance capability, deploy sensors, locate or by-pass threat acts as a communications relay and remotely assess/report battle damage assessment (BDA).

Figure 2: Armed Robotic Vehicle (with communication relay and anti-tank weapon mounted)

The Small Unmanned Ground Vehicle (SUGV) (figure 3) is a small, lightweight man portable UGV capable of conducting military operations in urban terrain, tunnels, sewers and caves. The SUGV helps in enabling the performance of manpower intensive or high-risk functions (i.e., Urban Intelligence, Surveillance and Reconnaissance (ISR) missions, Chemical/Toxic Industrial Chemicals (TIC)/Toxic Industrial Materials (TIM), Reconnaissance, etc.) without exposing soldiers directly to the hazard. The SUGV mini design allows multiple payloads to be fused in and with a plug-and-play option. Weighs less than 13 kg, it is capable of carrying up to two kilo of payload weight. Intelligent wireless sensors can be employed in order to attain enhanced surveillance [16,17].

Figure 3: Small Unmanned Ground Vehicle (SUGV)

The Multifunctional Utility/Logistics and Equipment (MULE) Vehicle is a 2.5-ton Unmanned Ground Vehicle (UGV) that supports dismounted operations (figure 4). It consists of four major components: Common Mobility platform (CMP), Three Mission Equipment Packages: Mule-Transport, ARV-A-L and Mule- Countermine, Centralized Controller (CC) for

Dismounted operations and Autonomous Navigation System (ANS) mission payload package integrated on MULE platforms, Armed Robotic Vehicles and Manned Ground Vehicles (MGVs) to provide semiautonomous and leader-follower capability. This vehicle can be sling-loadable under military rotorcraft. The MULE Vehicle has three variants sharing a common chassis: transport, countermine and the Armed. Robotic Vehicle (ARV)-Assault-Light (ARV-A-L). The Countermine MULE Vehicle (MULE-CM) will provide the capability to detect, mark and neutralize anti-tank mines by connecting mine detection sensors. The ARV-Assault-Light (ARV-A-L) MULE Vehicle is a mobility platform with an integrated weapons and reconnaissance, surveillance and target acquisition (RSTA) system to support the infantry to locate and destroy enemy vehicles and bases. Wireless mine sensors can be employed for detection, marking and neutralizing anti-tank mines in unattended environments. As the MULE vehicle is mobile in nature, clustering can be employed in gathering information collected from different MULE vehicles [8,12,13].

Figure 4: Multifunctional Utility and Logistic/Equipment support vehicle (MULE)

The Class I Unmanned Aerial Vehicle (UAV) provides the infantry soldier with Reconnaissance, Surveillance and Target Acquisition (RSTA) (figure 5). Estimated to weigh less than 16 kg, the air vehicle operates in urban, forest and mountain terrains with a vertical take-off and landing potential. It can be easily controlled by an infantry soldier. The Class I UAV incorporates autonomous flight and navigation but it interacts with the network and the soldier to periodically update routes and target information which is defined by the soldier or by C2V. It provides real-time video streaming with improved reconnaissance support and early warning to Brigade Combat Team (BCT) in environments which is not suited to larger assets like B-52 and SU-30. It also acts as a communication relay in restricted terrain like mountains, bunkers and inside the buildings. The system (which includes air vehicles, a control device and ground support equipment) is back-packable. Wireless sensors can be incorporated with these vehicles in order to attain superior surveillance and target acquisition. The Class II Unmanned Aerial Vehicle (UAV) has twofold endurance and a wider range of capabilities than the Class I. It is a multifunctional aerial system possessing the Vertical Take-Off and Landing capability. It supports the infantry soldier with reconnaissance, early warning, target acquisition and locating. It differ from class I UAV in capabilities like target designation in day, night and adverse weather. This provides the infantry the ability to study the battle space from far away by using a combination of Line-of-Sight (LOS), Beyond-Line-of-Sight (BLOS) and Non-Line-of-Sight (NLOS) systems. The Class II Unmanned Aerial Vehicle (UAV) can be carried by two soldiers.

Figure 5: Class I UAV

The Class III Unmanned Aerial Vehicle (UAV) is a multifunction system which has the range and endurance to support infantry with reconnaissance, surveillance and target acquisition. The Class III has to maximize endurance and payload while minimizing maintenance, fuel and transportation requirements. It can be used for communications relay, mine detection, Chemical, Biological, Radiological, Nuclear and High-yield Explosive (CBRNE) detection and meteorological survey. It allows the Non-Line-of-Sight (NLOS) precision fire for BCT in their area of interest. It operates at high altitudes during day, night and hares weather conditions. Wireless sensor network with weather, light and object sensors can be greatly employed with these vehicles so as to monitor these parameters in a remote manner [9, 16-23].

Figure 6: Class IV UAV

The Class IV Unmanned Aerial Vehicle (UAV) has a longer range and endurance (figure 6). It supports Brigade Combat Team (BCT) Commander with communications relay, long endurance and wide area surveillance. Class IV can also be used for aerial support. It has the capabilities of Wide Band Communications Relay, long-range Chemical, Biological, Radiological, Nuclear and High-yield Explosive (CBRNE) detection. In addition, it has the payload to augment the RSTA capability by cross-cueing multiple sensors.

III. CONCLUSION

Future combat system (FCS) is a network, which connects eighteen individual weapon scheme connected with the soldier all the way through the network. Supporting the soldier with real time situational awareness and cooperative operability among forces to entire a mission successfully with low mortality rate is the fundamental thought, thereby enabling the soldier to see first, understand first and take action decisively. Fusing the data collected from dissimilar reconnaissance vehicle, unattended ground sensors, unmanned aerial vehicles and live assets has to be made successfully. System of system common operating environment (SOSCOE) supports the system, providing reusable software design for platform and battle command application via low bandwidth network. After the comprehensive study on the problems and issues concerning FCS, two foremost criterions have to be accounted principally: battery lifetime and reliable communication over disrupted terrains. These two issues could be greatly minimized by replacing the sensors with wireless sensors embedded with a distributed clustering protocol like, Low Energy Adaptive Clustering Hierarchy (LEACH) [10].

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