INTEGRATED SURVEILLANCE PROTOTYPICAL SYSTEM IN ACCORDANCE WITH NEC PRINCIPLES

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ABSTRACT

The NEC requirements as flexibility, rapid reaction, resilience, fast deployment, high level automation, modularity, plug & play have a key role in modern surveillance architecture definition. This article describes the guidelines adopted to develop a CIP (Critical Infrastructure Protection) tactical architecture designed to fulfil them. This one is developed for a Harbour Protection (HP) and Land Protection application with the aim to protect an area against asymmetric threats. SELEX Sistemi Integrati has been given the chance to show its HP prototypical version in the occasion of the NATO Harbour Protection Trials 2007 (Taranto, Italy) and 2008 (Eckenfoerde,Germany) and the LP one during Italian Armed Forces manifestation in Cecchignola, Rome.The CIP system integrates different types of sensors (e.g. radar, IR, TV, SONAR) and classes of vehicles (Surface, Underwater, Air Unmanned Vehicles) which cooperate in a multi environmental scenario (above water, under water, sea surface, ground and air). The focus is to develop the following functionalities: fuse, classify, identify and present all the data provided by the sensors and consequently generate warnings on the Command and Control (C2) and interactive automatically with the console.The integration is performed to guarantee flexibility and modularity by means of tactical gateways developed in order to decouple the C2 system from sensor systems and vehicles. In particular, these gateways are designed to translate the subsystem proprietary data in a unique format. This allows to integrate every kind and numbers of systems tailoring each time the specific gateway without modifying sensors, vehicles or C2. The system shows NetCentric features and a wide set of growth above capabilities, even vehicles/sensors swarms, due to the gateway implementing a flexible middleware oriented to publisher/subscriber philosophy.

1. INTRODUCTION

SELEX SI adopted DoDAF methodology to derive system architecture from requirement and scenario. We refer to a typical “top down approach” ad described in Paragraph 3.0 In this article, we want to outline as our system and demo are according to NEC principle, in particular with “NETFORCE PRINCIPLES” [2]. Following the Plug In and Modularity principles, CIP SELEX SI architecture is the same for Harbour Protection (HP) System, called Archimede, and Land Protection (LP) System, named Anteo .

2. DRIVING PRINCIPLES

NEC starting points

- Enhance interoperability between systems and procedured
- To provide solution for all type of military application
- To allow legacy system or new component to be incorporated in system of system application (dynamically plug and play)

We refer in this article to the following definitions as in [1]:

Network-Node paradigm: all entities in a Netcentric operation can be regarded as simple or complex nodes interacting with each other through a communications network

SoS (System of System): Netcentric system formed by many subsystems

Netforce: the total collection of connected nodes that work together to perform a specific NEC

Network: the collection of nodes that perform communication and data distribution actions

Table 1 reports the basic **Netforce** actions and the node types which perform those actions. For each Node Types, SELEX SI architecture presents one or more module which performs those action.

Netforce Actions and Node Types		
Basic actions	*Node types*	
data collection	C	collector
information processing & provision	I	information provider
decision making	D	decider
taking action	E	effector
communicating	Com	communicator
providing support	S	supporter

Table 1: Netforce Actions and Node Types

Figure 1 outlines as the node, described in [1], could be linked and will be used latter to show as that figure

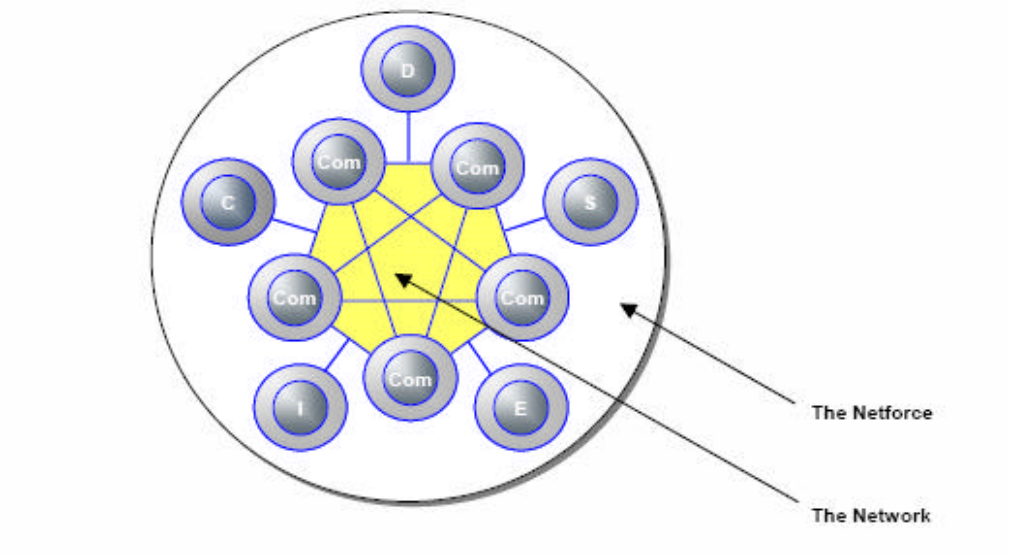

Figure 1: Netforce and Network

Basic principles (common understanding, common intent, synchronize effect):

- Generate a shared awareness by:
  - heterogeneous data collection
  - on demand data collection
  - data collection in a accurate and synchronized way
  - operational status collection
  - iterative understanding procedure
- Co-ordinate goals and synchronize actions starting from a :
  - Shared awareness
  - Use of the support providers
  - Accurate and synchronized

Basic nodes concepts

- Node interfacing in the netforce
  - Plug&play capability
  - Node resource management service
  - Status reporting functionality
  - Node control
- Node security
- Composite nodes (vedi 730+NEMO)
- Nodes types

3. CIP NEC ARCHITECTURE

3.0 Requirement and scenario

The system functions have been derived by the operational requirements and are scenario-compliant. The system is focuses on basic sensor functions:

- Search
- Detection
- Classification
- Engagement

The DoDAF [1] approach is considered as framework to support the project development.

SELEX Sistemi Integrati has been given the chance to show its HP system in the occasion of the Harbour Protection Trials 2007 (HPT07), which occurred from September 10th to 20th in Taranto, Italy. The HPT07 activities are part of the NATO Naval Armament Group (NNAG), which is led by the Italian Navy within the Conference of NATO Armaments Directors (CNAD) programs for the Asymmetric Threat Defence.

The demonstration was hosted and organized by the Italian Navy by the new "Mar Grande" Naval Station and had the purpose to test and evaluate the HP system overall performances both in terms of contact detection and threat warning capabilities, and in terms of smart use through its Human-Computer-Interface (HCI) from the professional operator's perspective. The NATO group responsible for the HPT08 demonstration had been attending the whole trial session to give its own contribution for the effectiveness evaluation of the proposed systems.

3.1 Referenced Architecture

The integration is performed to guarantee flexibility and modularity by means of tactical gateways developed in order to decouple the C2 system from sensor systems and vehicles. In particular these gateways are designed to translate in a unique format the proprietary data of sensor systems and vehicles; this allows to integrate every kind and numbers of systems tailoring each time the specific gateway without modifying sensors, vehicles or C2. This HP system shows NetCentric features and a wide set of growth above capabilities, even vehicles/sensors swarms, due to the gateway implementing a flexible middleware oriented to publisher/subscriber philosophy.

The system envisaged, created and proposed by SELEX Sistemi Integrati, was a prototypical system including a number different surveillance and detection sensors operating in the underwater, surface and air domains, and a core system able to fuse, classify, identify and present all the data provided by the sensors and the automatically generated warnings on an interactive console. By this console a single operator can supervise the evolution of the scenario with the possibility to manually intervene on the classification and identification

processes, manually re-direct the selected sensors towards the wanted direction, and eventually take his defensive actions.

The integration of different complementary technologies, as well as the convergence of the sensed data to a common central control point, has been fundamental in order to obtain a robust, accurate and reliable surveillance system. Not only but the set of technical solutions adopted developing HP System, permits to define this System as a prototypical example of NEC architecture. The coherent integration of sensors, decision-makers and the effectors permits HP System the better use of information towards the goal of "right information, right place, right time - and not too much".

To reach this aspect, the system is to interconnect the various sub-systems using a middleware that is able to meet the critical real-time performance requirements needed by this demanding application.

The C2 receives all sensor data (e.g. tracks, video...) and fuses track data in order to have one “system track” for each Real World Object present in the scenario to produce the *Common Operation Picture* (COP).
On this tactical picture, dangerous behaviours are detected to trigger alarms and inherent reaction. The system architecture is designed to fulfil NEC requirements in the HP scenario through the use of tactical gateway systems. A single operator can supervise the evolution of the scenario with the possibility to manually operate on the classification and identification processes, re-direct the selected sensor towards a required direction, and eventually take its defensive actions.

The C2 is composed by three blocks:

a. *Tracks Fusion*: it is a prototype based on Naval Multi Sensor tracking principles, with the aim to fuse the tracks provided by various RADARs;

b. *On Line Monitoring:* this system supports a user interface to let the operator have a clear COP (Common Operational Picture) and to give him the opportunity to designate unmanned vehicles and electro-optic sensors directly from its display. The On Line Monitoring is able to present sensors location, vehicles position, system or single radar tracks (using different icons for different threatening levels) and upon-request TV or IR videos, using different types of mapping files or satellite imagery;

c. *Treats Evaluation:* this module is now physically integrated in the Tracks Fusion module and it assigns the fused track the threatening level sorted out from an algorithm based on cinematic considerations.

d. SSM (System Managmen Monitoring)

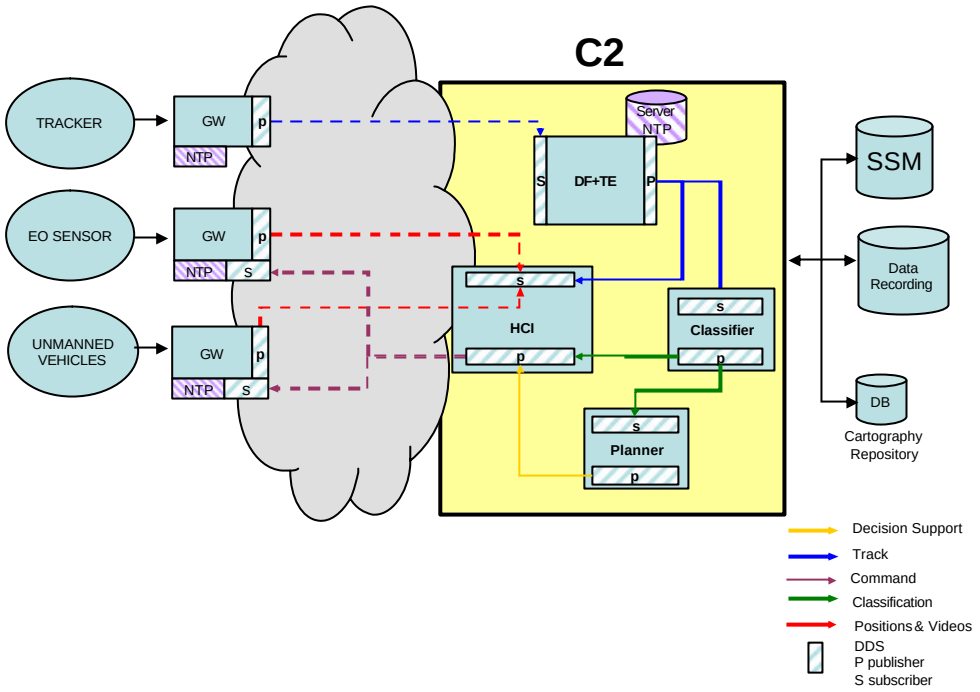

Figure 2 : Referenced Architecture

3.2 NEC principles and Referenced Architecture

SELEX SI identified nodes and corresponding type :

- Operator (D)
- Information processor (D)
- Uxv (E)
- Mobile sensors (C)
- Fixed sensors (C)
- Legacy systems (I)
- Composite nodes (C,I)
- Performance evaluators (S)
- Local integration (I)
- Local network (Com)
- Central network (Com)

Node types		SELEX SI Node Type	Example
C	Collector	Trackers e EO	RADAR, SONAR, acoustic tracker, TV, IR
I	Information provider	Gateway	One GW for each subsystem
D	Decision making	Operator	One operator, Threat Evaluation, Planner
E	Effector	Unmanned vehicle	UGV, UAV, UUV
Com	Communication	TLC	Hiperlan, WiMAx
S	Support	Decision Support	Planner, SSM, Data Recording, Data Fusion

Figure 3: SELEX SI Nodes

4. NODE AND NODE INTERACITON

4.1 Collector

RADAR equipment: each integrated RADAR sends its own tracks and its position not only to the Tracks Fusion but also to the On line Monitoring directly through the gateway. In both cases they don't receive any feedbacks.

E/O equipment: the electro-optical sensors play a key role in the surveillance task. They are used to detect, localize, track, and eventually identify potential threats and aid the guidance and the control of the unmanned vehicles used to intercept the threats. Each sensor sends its own position and TV and IR videos directly to the On Line Monitoring through the gateway;

4.2 Information Provider

Gateway

While the Trial Monitoring is the system core, the gateway system is the "glue logic" of the system. In fact, it represents the interface among the subsystems and the C2, translating the sensor data format into common and standard format. Its key role is pointed out by the DDS (Data Distribution System) middleware utilisation. The publish-subscribe paradigm of DDS enables systems to share data, creating a unique interface for all class of system: radar, sonar, electro-optics and unmanned. All the applic ation needs to do is to subscribe to the desired data sets and DDS does the rest. Using standards-based interfaces such as DDS permits not only simplified system maintenance, but also the possibility to change or integrate new subsystems without requiring a rewrite of the application software.
This technical choice was made with the aim to guarantee high performances with a NEC philosophy to approach communication and the possibility to "plug&play" new components with minimum effort.
The data managed by DDS middleware is composed by video, data from single sensor or effectors (e.g. track data, position, status, synchronization). From technical point of view a single IP networking infrastructure is capable of carrying all three kinds of traffic.
The need for flexible, adaptable, agile, information sharing environment means that subsystems should not have to connect to different networks to send and receive different types of information. In effect all subsystems need to be accessible through a single virtual network across which any type of information can be transported. In addition, the idea of being able to extend this network to wherever it may be needed across static, deployable and tactical domains means that this single virtual network should be able to utilize whatever type of transmission media that a user may have access to.
An important system capability is that it is able to integrate legacy systems too. In fact is not possible to create a new set of capabilities based on new operational requirements starting from scratch. "Legacy" is often associated to "old" or "obsolete". To the contrary, however, legacy systems refer to those systems that are currently operational and will be so for as long as their capabilities are required (or their replacement is not possible).
This means that they need to be integrated by using standardised interfaces rather than changed in some of their components in order to adapt them to the new paradigms or, worse, re-created following the new architectural styles. This is another reason for which we developed a standard tactical gateway.

4.3 Decision Making / Planner

This module has the aim to plan the location of fixed and mobile sub system. To aim is to support the operator in the decision making process.

4.4 Effector

Unmanned Vehicles: Unmanned Vehicles (UXVs) are defined as powered aerial, surface and underwater vehicles that do not carry any human operator, can move autonomously or be piloted remotely, can be expendable or recoverable, and can carry sensorial payloads. Each sensor sends its own position and receives from designations and commands the On Line Monitoring through the gateway.

4.5 Communication

The Network Infrastructure used in SELEX SI CIP projects is based on Hiperlan or WIMAX wireless communication or through the use for physical connection (i. e. optical fiber)

4.6 Node Interaction

The main node interactions in SELEX SI CIP projects are:

- Sensors –composite systems (C-I, information creation)
- Operator – uxv (D-E) effector assignment
- Legacy system – information processor (I-D shared situation awareness)
- Information processor-operator (D-D synchronized decision making)

5. CONLUSION

The HPT07 and HPT08 trials have been a great chance to test the system within its own application environment and to sort out a set of useful considerations to lead its future upgrades and to identify its growth capabilities.
The integration of different complementary technologies, as well as the convergence of the sensed data to a common central control point, has been fundamental in order to obtain a robust, accurate and reliable surveillance system.
Multi-sensor surveillance is the key for wide area coverage as a single sensor is unable to provide surveillance and to track a moving target over the entire area to be protected; furthermore the situation awareness derived from the surveillance provided by a single sensor is fragmented, incoherent and inconsistent, without all the benefit of data fusion and correlation to present a picture derived from the contribution of all the information sources of a multi-sensor system.
The fusion and correlation processes considerably enhance the operator's pro-active monitoring function, since it would be impossible/ineffective whether he/she had to monitor a wide area by looking at numerous displays because of their sensorial overload: this facilitated the mis-/under-evaluation of a significant/possibly critical amount of information.
The HP system provides an off-the-shelf human interface that integrates a common frame of reference for making the union of all sensory data coherent and consistent within a shared context of geographic and spatial relationships; besides, the HP system offers the great advantage of being open to accept different kinds of sensors for different operational situations through its flexible implemented middleware.
Due to its mentioned flexible middleware, the HP system shows a wide set of growth capabilities: one of the most important is the implementation of underwater sensors (mid/high frequency SONARs, divers detection SONARs, SONAR arrays, etc.) and other remotely-operated/autonomous underwater vehicles; another growth capability to be soon explored is the study and implementation of vehicles/sensors swarms.

6. ABBRIEVATION LIST

CODE	DESCRIPTION
C2	Command & Control
CIP	Critical Infrastructure Protection
DB	Database
DDS	Data Distribution Service
EO	Electro Optical
GW	Gateway
HMI	Human Machine Interface
IR	Infra Red
NTP	Network Time Protocol
SSM	System Status Monitoring
TBD	To Be Defined
TLC	Telecommunication
UAV	Unmanned Air Vehicle
UGV	Unmanned Ground Vehicle

7. REFERENCE

[1] DoDAF "Department of Defence Architectural Framework"

[2] NETFORCE PRINCIPLES "An elementary Foundation of NEC and NCO" Hans E. Keus TNO Defence, Security and Safety

[3] SELEX SI TALOS SYSTEM S. Borchi, M. Cresta, R. Massimelli, D. Benedetti, E. Storti