DYNAMIC AND AUTOMATIC CONFIGURATION OF DISTRIBUTED HETEROGENEOUS SURVEILLANCE SYSTEMS

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Abstract

A concept for an automatic dynamic configuration of hierarchical heterogeneous surveillance systems is described. The configuration is based on a central Information Module (IM) which has access to data describing the characteristics and capabilities of all relevant system components. The description proposed is modular and based on XML standard. Every component must have at least one description file that contains capabilities of the component and their relevant technical characteristics. For complex components containing sub-components these descriptions are set up hierarchically and contain references to descriptions of sub parts. Data conversion, separation and fusion modules ensure easy configuration and adaptation to hardware peculiarities.

Between the system components direct communication links are normally used to make the system more robust. External systems (for example, command centers) can get information about available capabilities from the IM and can request needed services directly from the components.

Keywords: Distributed system, surveillance, hierarchical, heterogenic, automatic configuration, modular, XML

1. INTRODUCTION

Heterogeneous surveillance systems have strongly spread during the last years or have grown on account of new demands. Fraunhofer IOSB is developing and evaluating such systems for different application scenarios [1, 2]. Their adaptive application in different surveillance scenarios requires a rapid configuration of the systems to the topical demands. This rapid configuration of distributed heterogeneous surveillance systems is a challenge because not only every single component, but also the needed communication infrastructure has to be set up.

Within the research done at Fraunhofer IOSB, possible solutions for a flexible automatic system reconfiguration during a mission are examined and evaluated. In this article one conceptual setup for an automatic configuration of complex distributed surveillance systems is described.

2. SOLUTION CONCEPT

The proposed concept for an automatic dynamic system configuration is based on a (potentially redundant) central Information Module (IM), which has access to data describing the characteristics and capabilities of all relevant system components (Fig. 1). The IM must always know which components are on-line and what capabilities and functionalities they can provide. To guarantee the automatic "technical" integration of the components in the overall system, the IM must also “know” the technical details about the integration parameters of the abilities (network-addresses, interfaces, protocols, etc.) for all serving components to notify all interested users or consumers (humans and other components or systems). The communication between the system components as well as to external systems is made directly. This makes the system much more robust – especially under poor quality of the communication channels or heavy data load.

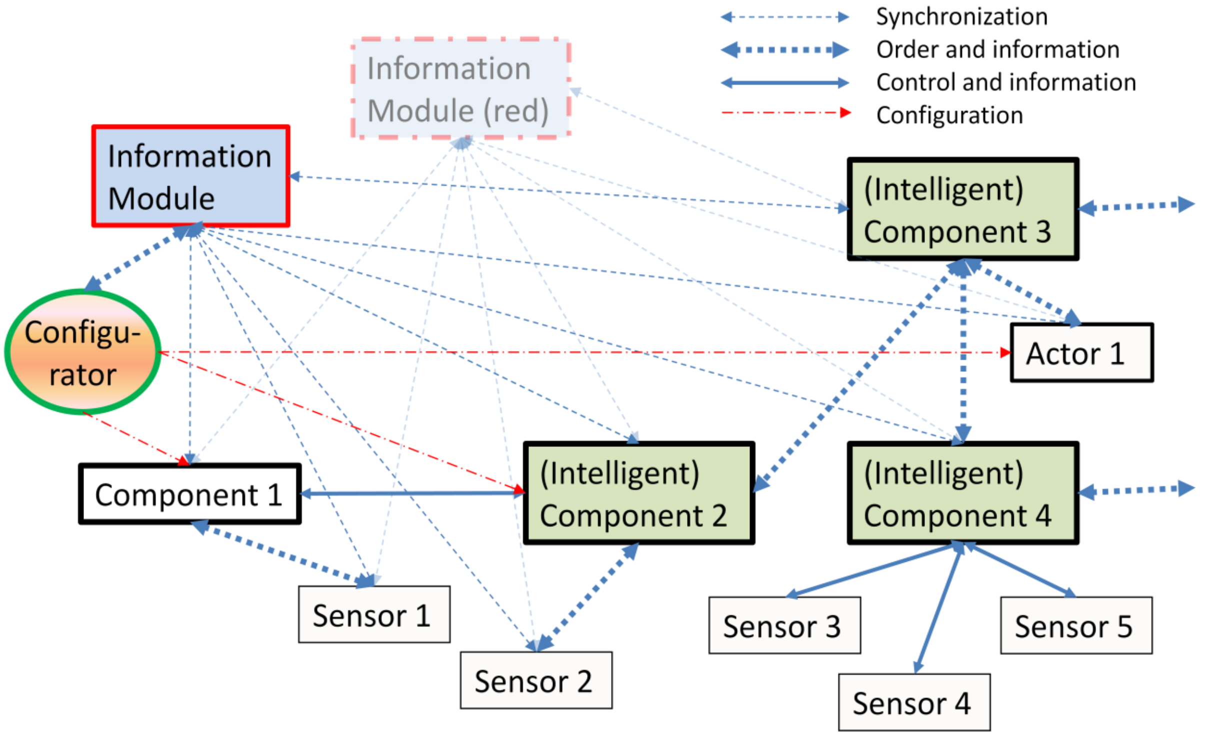

Fig. 1: A sample structure of automatically configurable distributed system with heterogenic components

The Information Module (or multiple IMs if redundancy is necessary) collects information about all connected system components. "Intelligent" components can inform the IM when connecting to the system or disconnecting from it, providing their own descriptions and report about changing capabilities, if needed. Simple components can be "installed" by introducing their abilities to the central IM before the first registration. During registration they only need to transfer their "call sign". The "intelligent" components should normally configure themselves, the special "Configurator" program can set parameters of different components and infrastructure (e.g. computers) as needed.

The central problem of such hierarchical heterogenic systems is the determination of consistent components' descriptions and interfaces at different hierarchy levels. The components and interfaces have very different complexity – from easy temperature sensors up to distributed command and control centers equipped with many sensors, sensor carriers, servers and workplaces, but all their descriptions must be standardized. Additionally, the same components may be used many times in different parts of the same system or in different systems with variable parameters, so that the descriptions should be easy adaptable. A sample of such complex distributed system is AMFIS [1] - an adaptable modular system for managing heterogenic mobile as well as stationary sensors. The main task of its ground control station is to work as an ergonomic user interface and a data integration hub between multiple sensors mounted on light UAVs (unmanned aerial vehicles) or UGVs (unmanned ground vehicles), stationary platforms (network cameras), ad hoc networked sensors, and superordinated control centers (Fig. 2).

Fig. 2: AMFIS - mobile ground control station for surveillance and reconnaissance

The description proposed is modular and based on XML standard. Every component must have at least one description file that contains two parts: 1) capabilities of the component and 2) their relevant technical characteristics. On account of this information, other subsystems can interoperate directly with this component and use its propagated functions and abilities. The "Configurator" program can also set up the component if needed. For complex components containing many sub-components and abilities, these descriptions are organised hierarchically and contain references to descriptions of sub parts, e.g. cameras, communication devices. On this occasion, the research about the necessary level of details which permits an automatic configuration using the descriptions of the single components is of central relevance. Is the description level too coarse, functions might not be correctly used or actions lead to unexpected or undesirable reactions. On the other hand, a too high description level produces abundance in information and needs a lot of expenditure in the generation of the descriptive data. In Fig. 3 a very simplified description of an easy configuration of AMFIS is shown.

The control station accepts for example reconnaissance orders and XMPP requests and can deliver videos and IR videos (as streams) as well as photos. It includes an UAV of type AeroRobot 120 and an AXI camera as well as downlink and uplink for wireless communication with the UAV (described in section <contains>). The detailed descriptions of sub-components are in linked XML files, so that main file mustn't be very complex and contains the information at the appropriate hierarchy level only. The UAV receives movement commands and can deliver a video stream from the infrared camera – only capabilities on this level are needed for the AMFIS central control station. The files for mobile components don't contain coordinates, because actual coordinates will be reported dynamically. The detailed descriptions of subcomponents of the UAV are in linked XML-files as well.

```xml
<?xml version="1.0"?>
- <item>
    <version>0.02</version>
    <name>AMFIS Karlsruhe</name>
    <category>control center</category>
    <type>AMFIS</type>
    <mobile>false</mobile>
    <position>14.5001:6.32:0.0</position>
  - <capability>
    - <input>
      - <reconnaissance_order>
          <host port="8888" IP="10.1.2.42"/>
        </reconnaissance_order>
      - <request_xmpp>
          <host port="3775" name="amfis1"/>
        </request_xmpp>
      </input>
    - <output>
      - <video>
          <host port="7004" IP="127.0.0.1" mode="MULTICAST"/>
        </video>
      - <photo>
          <host port="3778" IP="10.1.2.42" request="image.jpeg"/>
        </photo>
      - <videoIR>
          <host port="3780" IP="10.1.2.42" request="video.mpeg"/>
        </videoIR>
      </output>
    </capability>
  - <contains>
    - <item>
        <name>AeroRobot</name>
        <category>carrier</category>
        <type>UAV</type>
        <mobile>true</mobile>
        <desc>AeroRobot_120_IR.xml</desc>
      </item>
    - <item>
        <name>Downlink</name>
        <category>channel</category>
        <type>receiver</type>
        <mobile>false</mobile>
      - <value>
          <digital>true</digital>
        </value>
        <desc>DJI_24G.xml</desc>
      </item>
    - <item>
        <name>Uplink</name>
        <category>channel</category>
        <type>sender</type>
        <mobile>false</mobile>
      - <value>
          <digital>true</digital>
        </value>
        <desc>DJI_LK24-BT.xml</desc>
      </item>
    - <item>
        <name>AXICam</name>
        <category>sensor</category>
        <type>Camera</type>
        <mobile>false</mobile>
        <position>14.5002:6.32:0.0</position>
      - <value>
          <IP>10.1.2.22</IP>
        </value>
        <desc>AXI_M3025-VE.xml</desc>
      </item>
    </contains>
  </item>
```

Fig. 3: Simplified XML description of AMFIS

Another component of AMFIS on the same level as the UAV is a rotable AXI camera. Because its IP-address can be configured, the IP is set with parameter “value” in the main file. The camera position is aside of the AMFIS control station and is known. The description of the camera is shown in Fig. 4:

```xml
<?xml version="1.0"?>
- <item>
    <name>AXICam</name>
    <category>sensor</category>
    <type>Camera</type>
    <mobile>false</mobile>
    <rotable>true</rotable>
  - <capability>
    - <input>
      - <rotation_command>
          <host port="4475" IP="value"/>
        </rotation_command>
      </input>
    - <output>
      - <video>
          <host port="3740" IP="value" request="axi-cgi/mjpg/video.cgi"/>
        </video>
      </output>
    </capability>
  </item>
```

Fig. 4: XML description of AXI camera (simplified)

The camera receives rotation commands and can deliver video streams from IP “value” (set to “10.1.2.22” in Fig. 3) by setting the next request on port 4475: "AXI-cgi/mjpg/video.cgi”. The file in the sample contains no links to subcomponents, but for real automatic configuration the rotation commands, zoom etc. should be also described in a file.

All capabilities of a higher level component delivered from lower levels components must be described on the lower levels. For example the video output from IP "127.0.0.1" and port "7004" (Fig. 3) can be delivered from the AXI camera via IP “10.1.2.22“ and port "3740" by sending request "AXI-cgi/mjpg/video.cgi". Because the camera IP can be configured, it is described as parameter one level higher (<value> in Fig. 3), by that the camera description can be used also for other configurations without changes. In our case the “Configurator” must set the right camera IP.

Fig. 5 shows dependencies between the XML description files in our sample:

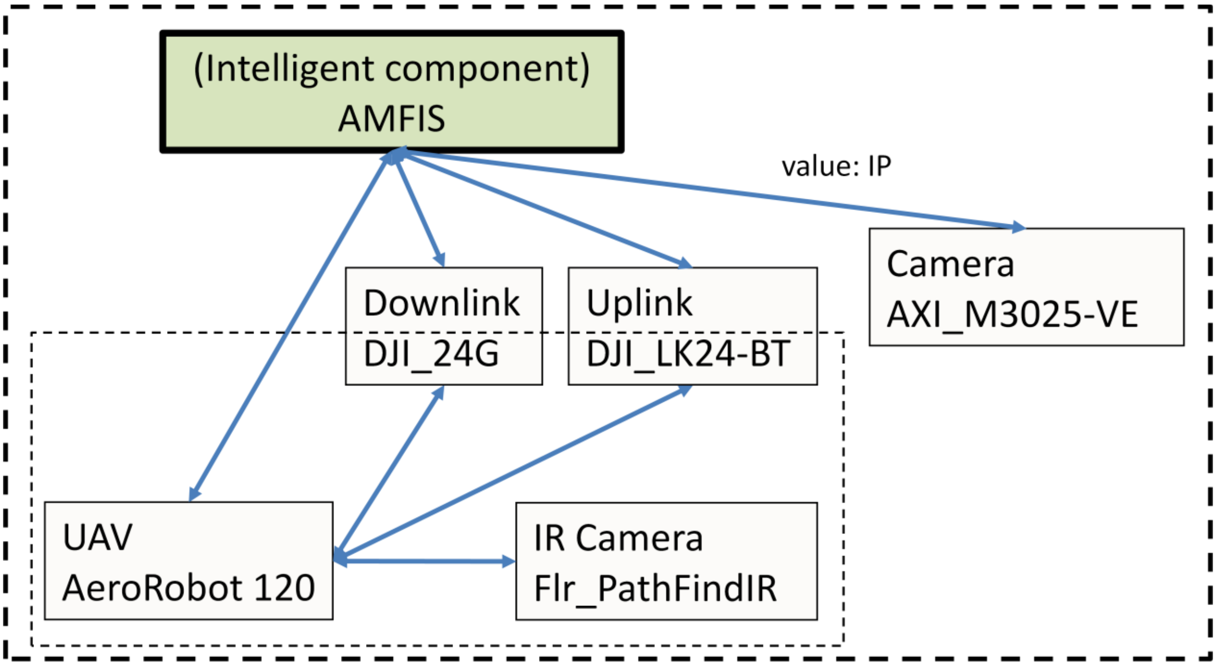

Fig. 5: Dependencies of used XML files

The communicatiuon links in Fig. 5, described in the two files are linked to the AMFIS as well as to the AeroRobot descriptions because they communicate via these components.

To ensure correct automatic configuration, the XML description must contain all information needed to set up wired and wireless communication – extern and intern. Additionally, all components need appropriately configured computers and communication channels, but not all of them are appropriately configured by default or able to configure themselves, so that in many cases a “Configurator” program must be used to ensure automatic communication. After configuration, system components communicate directly as needed on the basis of the information from the IM. In Fig. 6 information and data transfer in the sample system is shown.

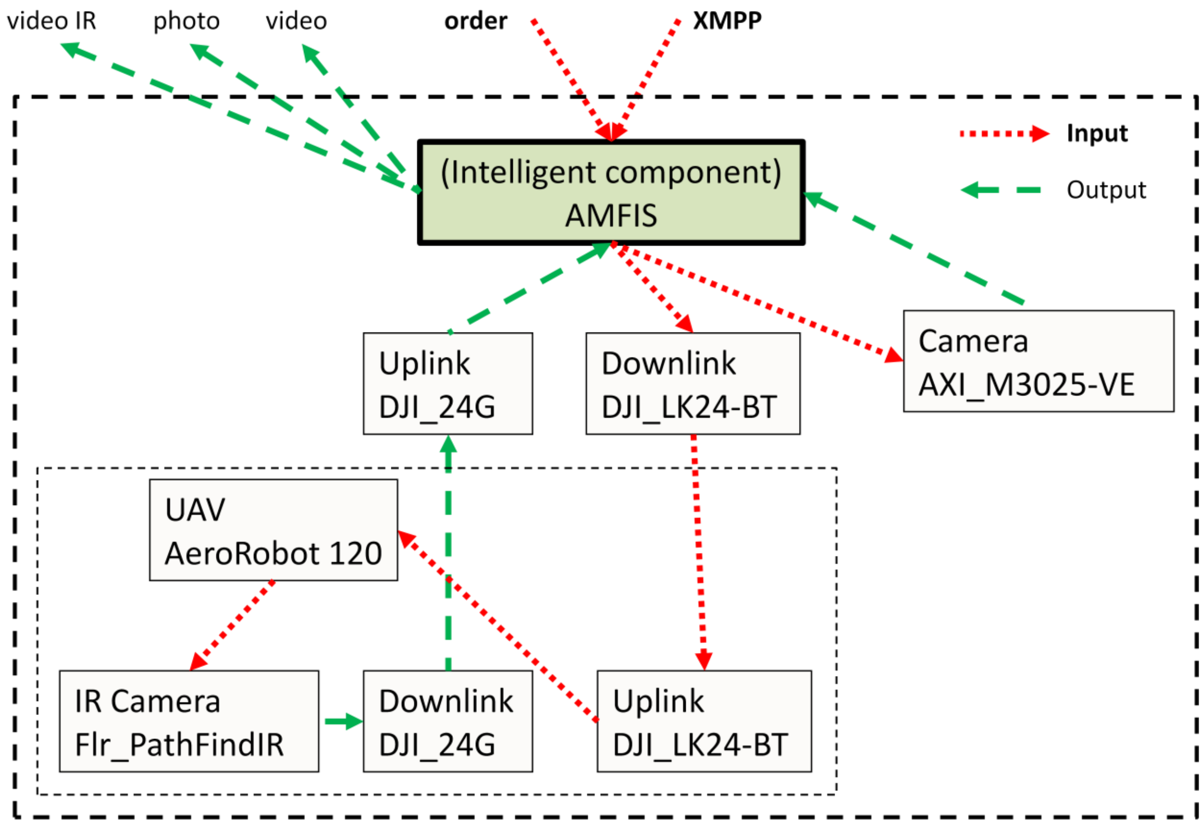

Fig. 6: Information and data transfer

External systems (for example, command centers) will get information from the IM about available capabilities and request needed services directly by the components. They must implement the access to information about the capabilities available from the IM – this service must be also standardised and have appropriate descriptions.

A particular challenge is the specification of reusable software supporting automatic configuration in heterogenic systems. To ensure a generic solution, suitable classifications of sensors, sensor carriers, communication channels, input and output devices are needed. A sample of a sensor classification according to type of information is shown in Tab. 1.

Dimension	Direction dependent	Sample sensors
0	No	Temperature, pressure, motion detector, non-directional microphone
0	Yes	Distance, velocity, force
1	Yes	Line scanning camera, microphone array
2	Yes	Video/IR camera, 2D Laser scanner
3	Yes	Radar, 3D Laser scanner, PMD, 3D Video/IR camera

Tab. 1: A sample of sensors classification

To support automatic configuration, the classification of each sensor group must be expanded with type of information compression (for AXI camera: uncompressed, MJPEG, MPEG2, MPEG4,...), resolution, frame rate and interfaces classification according to standard/protocol (both input and output, if suitable) like shown in Tab. 2.

Channel	**Wired**						**Wireless**		
Analog							Downlink		
Digital	USB		Ethernet				Downlink	WLAN	
	2.0	3.0	UDP	HTTP	HTTPS	RTP	...	...	...

Tab. 2: A sample of (simplified) 2D sensors classification according to standard/protocol

Sensor carriers' classification takes into account not only possible movement types like position changing/direction changing/combination and degree of freedoms, but also possible movement control: position, velocity or acceleration for each degree of freedom; absolute/relative values; correlations between coordinates; limits etc. Input devices can be classified on generated values, output devices on values that can be represented.

Based on the classification device-independent parent classes for each type of components can be developed. Additionally, device-dependent decoders and encoders for information, mixers and separators to prepare information for further analyze and transfer are needed. They also must be classified and suitable described. A (simplified) sample of an automatic configurable modular control and information analyzing pan-tilt camera system shows Fig. 7:

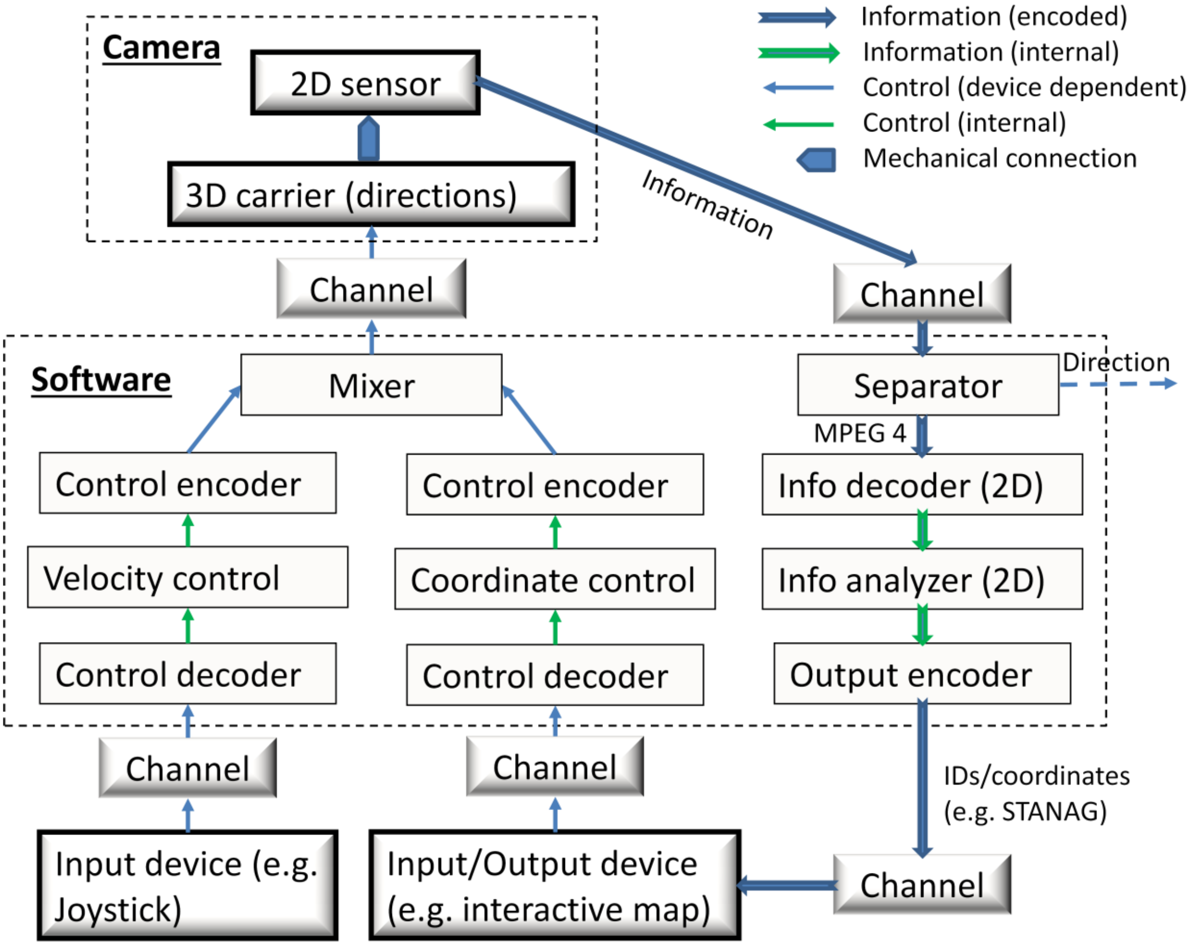

Fig. 7: Automatic configurable information analyzing and control system for pan-tilt camera

3. CONCLUSION

In this article a solution for automatic configuration of complex distributed heterogenic systems has been described. The concept is based on standardised modular descriptions of components containing technical and non-technical details. This concerns a long-term installation on its set up, but especially adaptive or expandable systems which must switch fast between certain configurations for different duties or change configuration by adding new components.

A sample of a hierarchic system description based on devices' classification and of adaptive modular software architecture is illustrated.

The results of this work will allow fast and adaptable automatic configuration of complex hierarchical systems and easy integration of new components.

REFERENCES

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