ENVISAT PRODUCTS SECURE BROWSING IN MOBILE CLIENTS USING JPEG2000 INTERACTIVITY PROTOCOL

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ABSTRACT

Taking advantage of the mobile platforms to interact with the HICOD2000 system has been the motivation for the work described in this paper. Regardless of the limited resources available in mobile platforms the authors demonstrate that using the features of the HICOD2000 system the mobile device might be of major assistance in the field where satellite imagery may have an important and useful role.

This paper describes an extension of the HICOD2000 system, available to the public through the ESA Service Support Environment. The EO JPEG2000 compressed products have achieved good compression ratios, minimizing both storage space and bandwidth. Regarding security to sensitive data the system enforces user access rights via a digital rights management platform called OpenSDRM. The mobile device has been endowed with the implementation of the JPIP protocol to optimize network bandwidth as well as the necessary components to interface with the OpenSDRM platform and decode JPSEC protected images: the OpenSDRM wallet and the protection tool.

1. INTRODUCTION

A system called HICOD2000, derived from a project developed in collaboration between two Portuguese partners and the European Space Agency that exploited the possibilities offered by the emerging image encoding standard – JPEG2000 – and its applicability to Earth Observation Products, has been the motivation for the work described in this paper.

In the HICOD2000 system all ENVISAT products where evaluated in their suitability for JPEG2000 lossless compression [1], resulting in the use of the following: MERIS [2], ASAR [3], GOMOS [3], ATTSR [5], RA2 [6] and SCIAMACHY [7, 8]. These products are coded in the ESA's proprietary format Payload Data Segment which has no compression at all resulting in quite large files unsuitable for interactive access over the Internet. The lossless compressed products using the JPEG2000 standard and stored in JP2 file format [9] have proved to achieve good compression ratios without information loss minimizing both the need of storage space as well the bandwidth for Internet transfer.

The current ESA's product delivery method is based on regular mail for sending the products in optical disks to the customer premises. To use an Internet based delivery method, security has to be a major requirement. In the HICOD2000 system, the EO JPEG2000 compressed products have been secured using the JPEG2000 standard Part 8: JPSEC [10]. This part of the standard allows a security granularity based on the image resolution the client acquires which is controlled and enforced via a digital rights management (DRM) platform called OpenSDRM [11]. The HICOD2000 was made available to the public through the ESA Service Support Environment (SSE). The system was entirely based on PC-platforms and the only way to access data was to have the interactive secure client viewer installed on a PC [12, 13].

However, mobility is becoming more and more a nowadays' requirement. A new paradigm is emerging - Anything, Anytime and, Anywhere is gaining more and more popularity, as new more powerful portable devices emerge on a daily basis – the connected PC is currently not enough for some EO data related applications. This new paradigm is a response to some activities needs and can be used to open the use of EO data related applications to a new array of services that, due to limited technical capacities of the mobile platforms, were until this date limited to the desktop PCs world. Events like the Asian tsunami or hurricane Katrina have shown that rescue operations are still far from optimal and that disaster area operation teams could benefit from the use of satellite images, on mobile devices, to coordinate and manage efforts on disaster areas. Other activities like agriculture, with concepts like crop scouting, that uses satellite images to identify patches of weed, draining problems or crop conditions, could also benefit with the appearance of new systems that allowed the use of EO data on a mobile environment. The identification of potential activities that could use this system is far from short and the authors can state a few more like outdoor sports activities, tourism, education, security, environmental management, etc. Having in mind the introduction of access to EO data in the Anything, Anytime, Anywhere paradigm the authors of this paper propose a new way to access ENVISAT products through mobile platforms, in particular SmartPhones and PocketPCs. However, being able to support JPEG2000 access in a mobile client platform

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requires being able to deal with the mobile platform limitations – low computational power, limited storage space, limited user interface, limited screen size and others. Therefore the mobile client had to be able to communicate with a remote server where EO JPEG2000 images are stored using an interactive mechanism which allowed to retrieve only the part of the compressed images needed for a particular view of the image. The JPEG2000 Interactivity Protocol (JPIP) defined in Part 9 of the JPEG2000 standard [14], was chosen for this purpose. This is a very powerful protocol because it reduces considerably the time needed to access a EO JPEG2000 product over a wireless network and because it reduces substantially the need to have a large storage space on the mobile client, since only the screen visible data needs to be locally cached.

The limited screen size of the mobile platform has important implications on the JPEG2000 visualization application, since it has to perform server requests focalized on these limitations. Having the visualized portion of the requested image in the client cache panning through the image only requires a few more bytes of data downloaded from the server. The security concerns present in the HICOD2000 project [12, 13] remain valid for the mobile platform. Satellite images often contain sensitive and classified information which must be protected from unauthorized users. Thus interfacing with the OpenSDRM platform to enforce user access constraints is a fundamental requirement. Having in mind these considerations the authors of this paper had to port the Kakadu library code (www.kakadusoftware.com) and the client-side component of the DRM platform, the OpenSDRM Wallet [11], to run in the mobile device. The visualization application integrates these two components to display both protected and unprotected EO JPEG2000 images downloaded from the server through the JPIP protocol.

2. ENVISAT PRODUCTS

The ENVISAT satellite contains a payload of eight measuring instruments. Each instrument is tuned to a specific range in the electromagnetic spectrum, mostly in the infrared, the microwave and the visible spectrum. Some instruments are pointed directly at the Earth's surface while others point obliquely at the atmosphere. Some are intended to image the earth under different viewing conditions while others are intended to measure physical quantities or concentrations of chemical substances. The instruments store the measurement data in raw format, and send it back to ground stations at specific locations in their orbit path. This raw measurement data is afterwards combined to form different EO product levels.

The resulting products are stored in the Payload Data Segment file format (PDS) which contains a Main Product Header (MPH) and a Specific Product Header (SPH) followed by product dependent data. Some products have Measurement Data Segments (MDS) where the measurement data is stored either in integer or floating point format, depending on the product. This data format does not feature any compression and so can usually result in quite large product files, not very suitable for Internet transfer. Knowing that the current JPEG2000 standard does not specify the manipulation of floating point data, each of the ENVISAT instruments products was evaluated (Figure 1) to determine it's suitability for JPEG2000 coding [1, 9], and as a result several have been identified: MERIS [2], ASAR [3], GOMOS [4], ATTSR [5], RA2 [6] and SCIAMACHY [7, 8].

		Suitable	Possible	Doubtful	Unsuitable
AATSR	ATS_TOA_1P	x			
	ATS_NR__2P	x			
	ATS_AR__2P				x
	ATS_MET_2P				x
	ATS_AST_BP	x			
ASAR	ASA_IMS_1P	x			
	ASA_IMP_1P	x			
	ASA_IMG_1P	x			
	ASA_APS_1P	x			
	ASA_APG_1P	x			
	ASA_APP_1P	x			
	ASA_WVI_1P	x			
	ASA_WVS_1P			x	
	ASA_IMM_1P	x			
	ASA_APM_1P	x			
	ASA_WSM_1P	x			
	ASA_GM1_1P	x			
	ASA_IM__BP	x			
	ASA_AP__BP	x			
	ASA_WS__BP	x			
	ASA_GM__BP	x			
	ASA_WVM_2P				x
DORIS	DOR_DOP_1P			x	
GOMOS	GOM_TRA__1P				x
	GOM_LIM__1P		x		
	GOM_EXT__2P				x
	GOM_NL___2P			x	
	GOM_RR__2P			x	
MERIS	MER_RR__1P	x			
	MER_FR__1P	x			
	MER_RR__2P	x			
	MER_FR__2P	x			
	MER_LRC_2P	x			
	MER_RRC_2P	x			
	MER_RRV_2P	x			
	MER_RR__BP	x			
MIPAS	MIP_NL__1P				x
	MIP_NL__2P				x
	MIP_NLE_2P				x
RA2/MWR	RA2_GDR_2P		x		
	RA2_MWS_2P		x		
	RA2_FGD_2P		x		
	RA2_IGD_2P		x		
	RA2_WWV_2P		x		
SCIAMACHY	SCI_NL__1P		x		
	SCI_NLC_1P				x
	SCI_NL__2P				x
	SCI_OL__2P				x
	SCI_RV__2P				x

Figure 1. ENVISAT 's products evaluation for JPEG2000 compression

3. JPEG2000 STANDARD

3.1. JPEG2000 Image Compression Standard

The JPEG200 image compression standard [1] brings not only powerful compression performance but also new functionality unavailable in previous standards (such as region of interest, scalability and random access to image data, through flexible code stream description of the image). The compression performance using JPEG2000 overcomes JPEG, with the drawback of a much higher complexity. For software and hardware platforms, the complexity of JPEG2000 is believed to be around ten times higher than JPEG [15]. This is a crucial problem for its adoption for real-time systems such as earth observation satellites.

JPEG2000 introduces flexibility in the transmission of images with a progressive improvement in image quality. The standard supports the capability of transmitting arbitrary regions of interest inside the image, with greater fidelity than others. It is also capable of providing lower resolution and/or low quality representations of an image for quick viewing, by only decoding a selected portion of the total transmitted image. JPEG2000 is able to code a wide range of images, from black and white, to greyscale, full-colour (24 bit/pixel) images, to hyper-spectral space and planetary images that typically contain several dozen-colour bands [15]. Another important feature is the ability to provide error-resilience during transmission; that is to say, an error during progressive transmission will only affect a small portion of the final image rather than the whole image. As it stands currently, an image than has been compressed to the same final size with JPEG2000 and JPEG, will show much less visible artefacts with the first, due to the increased ability of wavelets to represent an image at low resolution than with the later, where the individual 8x8 blocks become noticeable for large compression ratios (Figure 2). The two formats behave similarly for high quality reproductions but JPEG2000 increasingly outperforms JPEG as more and more compression is introduced, while maintaining the same visual fidelity [15].

Figure 2. JPEG (left) and JPEG2000 (right) low bit-rate comparison.

3.2. JPEG2000 Security

The issue of secure access to satellite imagery is sensitive, since they contain value that image producers and providers, think that requires protection. Part 8 of the JPEG2000 standard, called JPSEC [10] provides solutions to this problem by specifying a set of standardized tools and solutions that ensures security of transaction, protection of contents, and protection of technologies, allowing applications to generate, consume, and exchange JPEG2000 secured bit-streams. JPSEC addresses, among other applications: encryption (flexible mechanism to allow for encryption of image content and metadata), source authentication (verification of authenticity of the source), data integrity (data integrity verification), conditional access (conditional access to portions of an image or its associated metadata), ownership protection (protection of the content owner rights). In order to protect the content techniques such as digital signatures, watermarking, encryption, and key generation and management, are used.

3.3. JPEG2000 Interactivity Protocol

The JPEG200 standard Part 9 [14], defines tools for supporting delivery of image and metadata in the context of networked environments. Part 9 exploits JPEG2000 flexibility in relation to random access, code-stream reordering and incremental decoding in that context. Using a client-server protocol named JPIP that can be built on top of HTTP, which can handle several different image data types from the server. It also allows selective access to image metadata that might be included in JPEG2000 files. Part 9 is focused on JP2 file format, but also supports some file format extensions from Part 2 (JPX) [9]. It also defines mechanisms to provide selection amongst multiple code-streams in JPX, MJ2 and JPM files. Additionally, also defines new file format boxes for indexing JPEG2000 files and code-streams [14].

4. DIGITAL RIGHTS MANAGEMENT

An effective implementation of the JPSEC [17] was combined with a Digital Rights Management (DRM) solution, denominated OpenSDRM [11], which deploys protection and security, and controlled access to content and which is particularly relevant in the digital content e-commerce.
The OpenSDRM architecture (Figure 3) is adaptive [14], which means that it can be configure for use with several business models and different types of content.

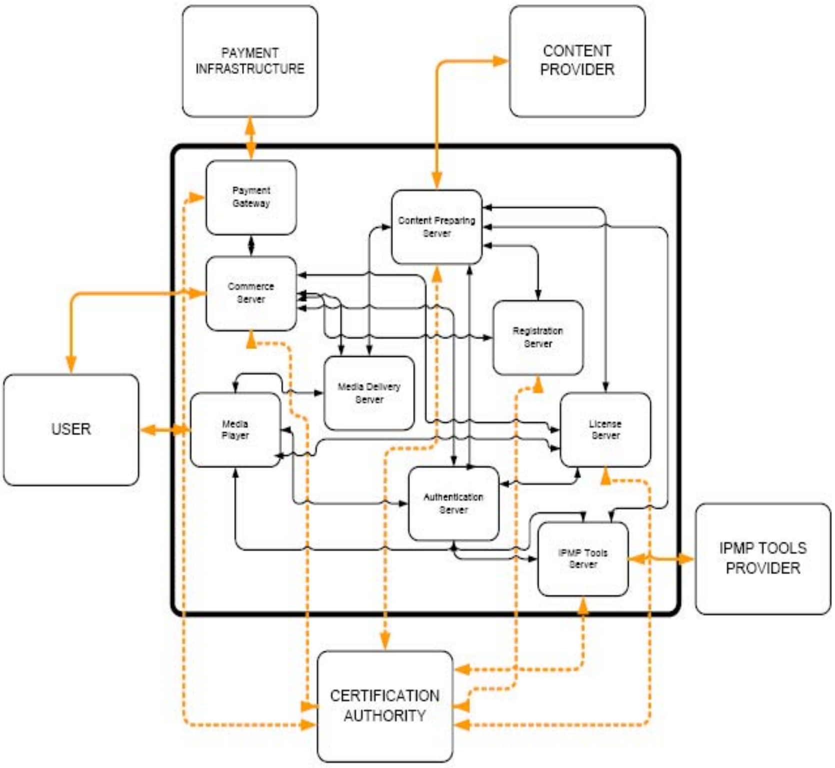

Figure 3. OpenSDRM system Architecture

OpenSDRM deploys a traditional DRM solution for content rights protection and can be applied for publishing and trading of space and planetary imagery. Additionally, the security architecture proposed is inline with the recent international specifications OPIMA, MPEG-4 and MPEG-21 as well with some of the proposals for JPEG2000 standard Part 8 – JPSEC – JPEG2000 security [10].

This DRM solution is composed of several optional elements covering the content distribution value chain, from content production (content author or producer) to content usage (final user). It covers several major aspects of the content distribution and trading: content production and preparation (Content Preparation Server, Registration Server), content protection (Registration Server, License Server, Intellectual Property Management and Protection - IPMP tools server and Authentication Server), content interactive distribution (Media Delivery Server), content negotiation and acquisition (Commerce Server, Payment Gateway), strong actors and users authentication (Authentication Server) and conditional visualization (Media Player, IPMP tools Server, License Server) [14].

5. HICOD2000 ARCHITECTURE

The HICOD200 system architecture (Figure 5) has three major components: the HICOD2000 Black Box (H2KBB); the OpenSDRM platform; and the SSE portal.

The H2KBB (Figure 4) is the component responsible for the parsing, encoding, and protection of the EO JPEG2000 products. The H2KBB is able to work with the ENVISAT product's format as well as with SPOT5 vegetation products [12]. To protect an image, using the JPSEC standard, the H2KBB communicates with the DRM platform through web services in order to obtain the necessary encryption keys.

The OpenSDRM platform has the responsibility of managing the encryption keys and access rules for the EO JPEG2000 products, as well as enforcing those rules when the users try to access the images.

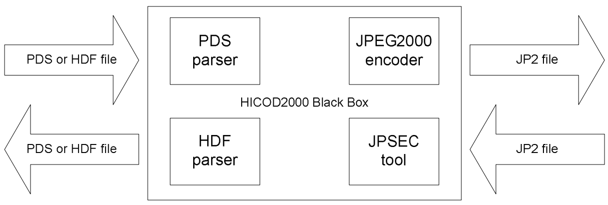

Figure 4. The H2KBB architecture.

The access to the HICOD2000 system is made available through the ESA's Service Support Environment (SSE). The integration with the SSE portal also uses the web services paradigm and is described in [12].

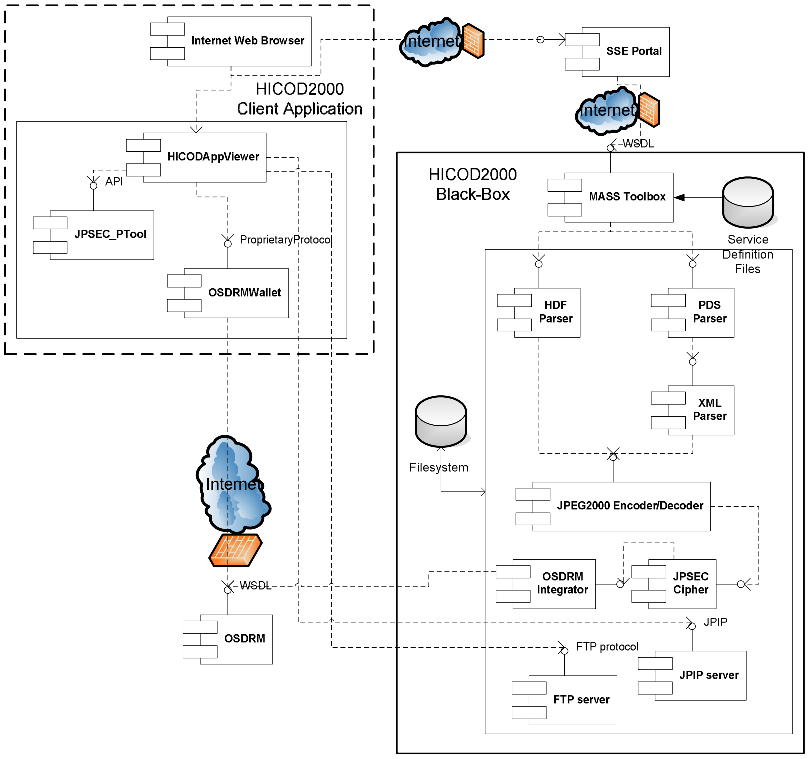

Figure 5. HICOD2000 architecture

6. MOBILE CLIENT

The HICOD2000 architecture (Figure 5) was designed to be extendable to allow the interaction with users that may be on the field. The development of a client application for mobile devices provides the necessary flexibility for this purpose.

Being a resource constrained device, the use of the JPIP protocol [14] allows the mobile client to interactively retrieve lower resolutions of the image, minimizing the needs for both high processing and storage capacities. Moreover, since mobile devices have small displays with relatively low resolution, the use of decreased resolution images does not have an impact on visual image quality.

The JPEG2000 images consumed by the mobile client are usually resource demanding becoming infeasible to download and visualize the whole image. The JPIP protocol [14] can respond to real-time application requests, delivering pieces of a JPEG2000 image in arbitrary order. In order to avoid the need to store multiple versions of an image at different resolutions and the retransmission of redundant data, JPIP takes advantage of JPEG2000's resolution hierarchy [14].

In JPIP the image delivery mechanism differs from conventional web image transmission. The latter requires the whole image to be transferred, using the HTTP protocol, from the server to the client. The client then decodes the image with a separate JPEG2000 decoder. The HTTP transport system is totally generic and has no information regarding the JPEG2000 images it may transfer. By contrast, JPIP allows the client to define a “focus-window” with the user's spatial region, resolution and components of interest [16]. The requests may have different image delivery options, which correspond to different data types for the server response [14]:

1. The server returns complete JPEG2000 images for a requested region at a specified resolution. The transfer has limited efficiency since there can be redundant retransmission of data when multiple requests are considered.
2. The server returns a new stream type called JPT stream. This can contain header data, sample data or metadata. The sample data is made of the tile-parts relative to the requested region of the image up to the requested resolution level. There is an increase in efficiency over the first option, since tile-parts that are pertinent to more than one request do not need to be resent.
3. The server returns a new stream type called JPP stream. The sample data is based on precincts at each resolution level. This is the most efficient image delivery option, since it does not have the scalability and spatial limitations of the second option, which are inherent to the tile oriented transmission.

The JPIP protocol is transport-neutral [14]. Its primary design objective is that transmission is made through

HTTP without interference with existing HTTP infrastructure. Nevertheless, other transports can be used even more efficiently (e.g. TCP or UDP).

Figure 6 depicts the interaction between the client application and the remote server, when using the JPIP protocol [19]. It should be noted that in this figure the decompression rendering process is separated from the client-server communication. It is also signalled the client's cache of data previously transmitted by the server, organized in data-bins. Optionally, the server may have a model of the client's cache to avoid retransmission of data the client had already received [14, 16].

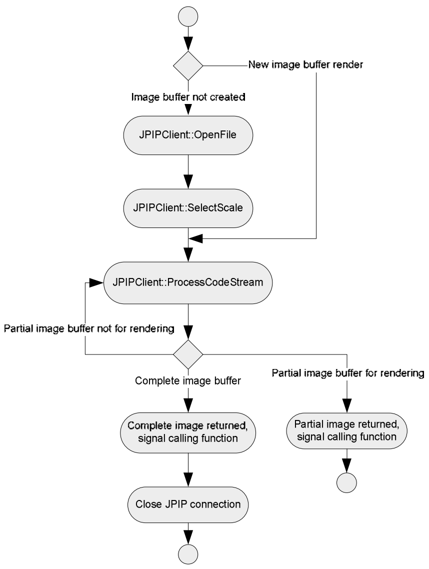

Figure 6.Client-server JPIP interactions.

The HICOD2000 system allows conditional access to images through the use of protection tools and rules. The protection tool developed has to consider the JPEG2000 code-stream constraints [1] to allow the decoding of the image by any JPEG2000 compliant decoder. Having that in consideration the protection tool implements the algorithm described in [18]. The access rules are enforced by the DRM platform. The mobile device client application communicates with the OpenSDRM platform via the wallet. The OpenSDRM wallet is a client component that manages and requests licenses to access protected images.

When accessing a JPSEC protect image the decoded image will be displayed as shown in ***Figure 7. JPEG2000 satellite image protected with JPSEC.***Figure 7. If the client has a license which will allow him to view the image or up to same resolution the wallet will deliver that license to the protection tool to decode the image so it can be displayed as in Figure 8. Whenever the client has a license which will not allow him to view a certain resolution or has no license at all, the OpenSDRM wallet will contact the DRM platform in order to obtain the required license, after the user pays the agreed value

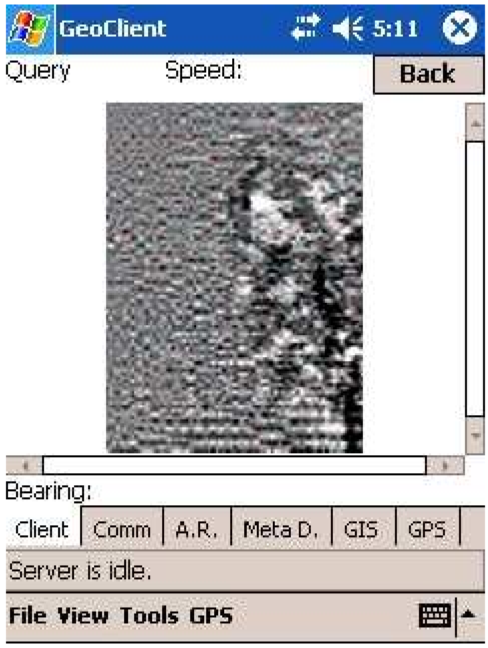

Figure 7. JPEG2000 satellite image protected with JPSEC.

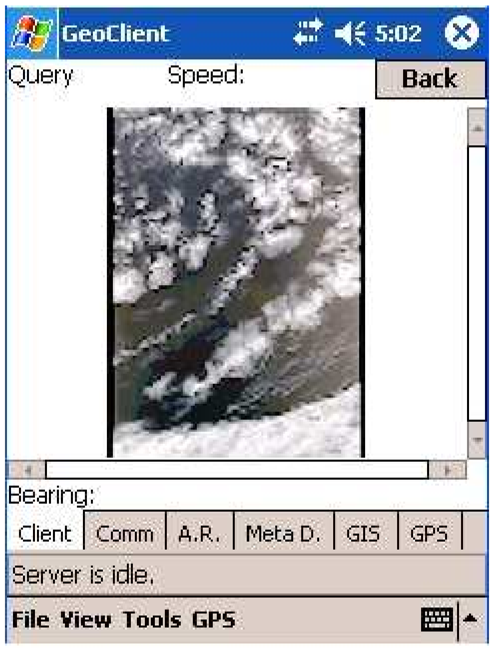

Figure 8. JPEG2000 satellite image after protection removed

7. CONCLUSIONS

In this paper the authors describe a new way to take advantage of the HICOD2000 system's potential: a mobile client application. Considering the limited resources of such a platform the use of the JPIP protocol is of up most importance. By taking advantage of the JPEG2000 resolution hierarchy, the mobile application is able to display a low resolution image with any visual effects maintaining the images lossless characteristics. Because some of the images may have sensitive or classified information, the use of JPSEC protect images on the mobile application was also considered. To achieve this goal the client component of the DRM platform, the OpenSDRM wallet, had to be ported to the mobile platform as well as the protection tool.

Being an emerging all use platform, the authors are convinced over the ever growing usefulness of mobile devices in any field of action, independently of the final use given to an application: disaster management and coordination; crop scouting and monitoring; and many others.

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