Definition and Generation of Level 0 Product for KOMPSAT-2

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According to the image level definition for KOMPSAT-2 in KOMPSAT-2 Ground Station Specification, the level 0 is frame formatted, unprocessed data at full resolution; *any and all communications artifacts (e.g., synchronization frames communications headers) removed.* The level 0 is used for two purposes: 1) exchange of imagery between image receiving & processing element (IRPE), and 2) image transfer from the Receiving & Archiving Subsystem to Search & Processing Subsystem.

On-board processing of imagery data of KOMPSAT-2 includes JPEG-like compression and encryption besides conventional CCSDS packetization. The encryption is used to secure imagery data from any intervention during downlink and compression allows real-time downlink of image data reducing data rate produced from the camera.

While developing ground receiving system for KOMPSAT-2, it was necessarily to define level 0 products. In this paper, we will suggest level 0 product definition for KOMPSAT-2 and explain reasons of the decisions made. The key factor used while defining the level 0 products is the efficiency of whole ground receiving system.

The latter half of the paper will explain the implementation of software that generates level 0 products. The necessary steps to produce level 0 products will be explained, and the performance achieved will be presented.

Key words: Level 0, KOMPSAT-2, CCSDS, IDEA

1. Introduction

The level 0 is an image level that *any and all communications artifacts (e.g., synchronization frames, communications headers) removed.*

The level 0 product is used for following two purposes.

1) Exchange of imagery between image receiving & processing elements (IRPEs)
2) Image transfer from the Receiving & Archiving Subsystem (RAS) to Search & Processing Subsystem (SPS)

While developing ground receiving system for KOMPSAT-2, it was necessarily to define level 0 products specification.

The KOMPSAT-2 has additional operations on downlink data compared to conventional middle-resolution satellite image. The KOMPSAT-2 applies compression and encryption on the downlink payload data besides CCSDS formatting. . The space segment of KOMPSAT-2 responsible for downlink formatting is the Payload Data Transmission System (PDTS). In PDTS, mission data may be compressed before stored to Solid State Recorder (SSR) to fit bandwidth limitations. The Channel Coding Unit (CCU) of PDTS processes mission data on SSR to transmission data format through encryption and CCSDS formatting such as packetization, Reed Soloman coding, randomization [elop2002]. The encryption is used to avoid data interception. Each IRPE has its own decryption keys and keys are not public key, hence deciphering should be done for level 0 products to satisfy the first purpose of level 0 products.

The content of level 0 product was suggested as data

as stored in SSR rather than decompressed data. In this way, we can achieve load balancing between RAS and SPS, guarantee constant performance of level 0 processing, save archiving storage required and save transmission time.

While defining the physical format of level 0 products, we considered two factors:

1) Level 0 product should be self-explanatory: Level 0 products should contain all information needed to extract image data from it. For this, we included compression related tables and data description in level 0 products.

2) Level 0 products should be easy to process in the pre-processing component. We proposed that the data is indexed by its line number for fast extraction of information.

The definition of level 0 format proposed will be described in detail in section 2. Section 3 explains steps to produce level 0 products and in Section 4, performance achieved presented. The conclusion and future works will be discussed in Section 5.

2. Definition of Level 0 format for KOMPSAT-2

The KOMPSAT-2 X-Band source data consist of 10 channels (instrument) imagery data, that are PAN1~PAN6, MS1~MS4. Each instrument is organized in lines. Each line is has line header produced by PDTS to preserve data as received.

Suggested level 0 product is designed to add some necessary information and to satisfy following requirements for easy and fast extraction of image data.

1) Ancillary data is separated from other image line data, and
2) It is possible to load image to memory through line number or image scan number (in case compressed).

The level 0 file is designed to compose 11 internal subfile, that is 10 instruments and ancillary. Each subfile is organized in lines or image scans, and indexed by line number to speed up extraction of an image. Ancillary data of 512 bytes obtained during 1 second are considered as one line and it is indexed by line number, too.

Figure 1 shows level 0 format for KOMPSAT-2. Data block is space for instrument data and ancillary data, and index block is space to record location of lines.

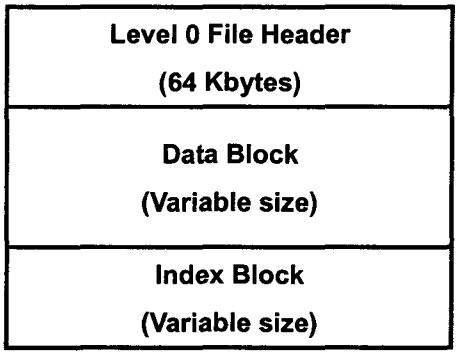

Figure 1 Structure of Level 0 File

2.1 Level 0 File Header

The level 0 file header is composed three parts. (Figure 2)

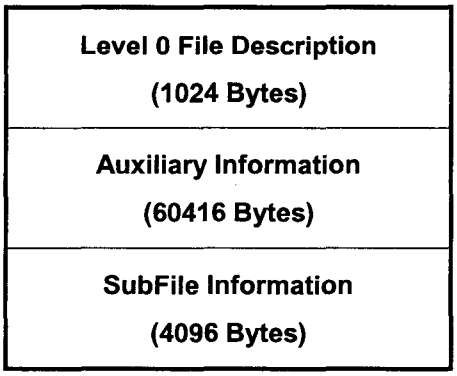

Figure 2 Structure of Level 0 File Header

The level 0 file description includes description of raw data used for level 0 product generation and information

of image data obtained from level 0 processing. (Table 1) Auxiliary information part includes additional information needed to extract image data, namely non-uniform quantization tables and huffman tables. They are necessary to decompress image. (Table 2)

Table 1 Level 0 File Description (1024 Bytes)

Description	Bytes	Contents	
Format indicator	20	"RASFILE Ver. 1.0"	Source data description (Grey part from source data)
Station name	10	Receiving station	
Work order ID	30	Work Order ID	
Receiving start Time	20	YYYY.MM.DD.HH:MM:SS (UTC)	
Receiving end Time	20	YYYY.MM.DD.HH:MM:SS (UTC)	
Satellite name	20	"KOMPSAT2"	
Sensor name	20	"MSC"	
Encryption	10	"Ciphered"/"Plain"	
Reserved	106	Reserved	
Level 0 file name			Level 0 File description
Station name	10	Processing station	
Producer	20	Processing operator	
SW version	10	Version information	
Processing time	20	YYYY.MM.DD.HH:MM:SS (UTC)	
Operation mode	10	"REALTIME" / "PLAYBACK"	
Sensors	20	"PAN Only" / "MS Only" / "PAN+MS"	
Imaging start time	20	YYYY.MM.DD.HH:MM:SS (UTC)	
Imaging end time	20	YYYY.MM.DD.HH:MM:SS (UTC)	
Compression	20	"Compressed" / "Not Compressed"	
RS decoding	20	"RS decoded" / " "	
CR	1	0x0d	
EOF for DOS	1	0x1a	
Reserved	582	Reserved	

Table 2 Auxiliary Information (60416 Bytes)

Description	Bytes	Contents
Reserved	1024	Reserved
Non-uniform quantization table #1	64	One table has 64 elements and an element
Non-uniform quantization table #2	64	
...	...	
Non-uniform quantization table #16	64	
Huffman tables #0	258	DC bits 16 bytes DC values 16 bytes AC bits 16 bytes AC values 210 bytes
Huffman tables #1	258	
...	...	
Huffman tables #31	258	
Reserved	50112	Reserved

The Subfile information includes name, first line number, number of lines and location of index of each subfile. (Table 3) The first line number is needed when first line number of subfile is not 0.

Table 3 Subfile Information (4Kbytes)

Description	Bytes	Contents
Subfile #0: Name	12	"PAN1"
Subfile #0: Size S_0	8	Size of subfile, U32
Subfile #0: Line start K_0	4	First line # of subfile, U32
Subfile #0: # of lines L_0	4	number of lines in subfile including missing lines, U32
Subfile #0: Offset T_0	8	Location of index from the beginning of level 0 file, U64
Subfile #0: Reserved	28	Reserved
Subfile #1: Name	12	"PAN2"
Subfile #1: Size	8	Size of subfile, U32
Subfile #1: Line start	4	First line # of subfile, U32
Subfile #1: # of lines	4	number of lines in subfile including missing lines, U32
Subfile #1: Offset	8	Location of index from the beginning of level 0 file, U64
Subfile #1: Reserved	28	Reserved
.....	...	.....
Subfile #10: Name	12	"ANCILLARY:
Subfile #10: Size	8	
Subfile #10: Line start	4	
Subfile #10: # of lines	4	
Subfile #10: Offset	8	
Subfile #10: Reserved	28	
Reserved	3392	Reserved. Support for max 64 subfiles

2.2 Index block

The index block saves location of each line of subfile. Figure 3 shows structure of index block. "N" is the number of subfiles which size is not 0. If the sensor is "PAN only", "N" equals 7 for KOMPSAT-2. For "MS only" mode, it equals 5, and for "PAN+MS" mode, it equals 11.

Index for subfile #0 (Variable size)
Index for subfile #1 (Variable size)
Index for subfile #2 (Variable size)
...
Index for subfile #N-1 (Variable size)

Figure 3 Structure of Index Block

The index consists of index elements for each line as shown in Table 4. The index element is divided to location (offset) and size of line. Each index element is saved sequentially according to the line number.

Table 4 Index

Line	Element	Offset	Bytes	Contents
K	Offset	0	8	Location of line K
	Size	8	4	Size of line K
K+1	Offset	12	8	
	Size	20	4	
K+2	Offset	24	8	
	Size	32	8	
...	...	...	...	...
K+L-1	Offset	12×(L-1)	8	
	Size	12×(L-1)+8	4	

3. Generation Level 0 Product

The KOMPSAT-2 downlink uses modified Version 1 CCSDS Packet format [CCSDS 102.0-B-4]. Figure 4 shows the format.

ASM	Primary header			Data	RS symbols
	Packet ID	Sequence control	Length		
4 byte	2	2	2	1115	160

Figure 4 CCSDS Packet format

The steps to produce level 0 product is following.

- **Synchronization**: detects the ASM (Attached Sync Marker: special symbols for synchronization) in the data stream. It covers one bit error of ASM.
- **De-randomization**: restores the header, data, R/S symbols using pseudo-random sequence pre-defined.
- **Reed Soloman decoding** : detects and corrects errors using R/S symbols. We can take statistics on quality of down link data though R/S decoding.
- **Decryption**: deciphers data block.
- **Separation segment**: separates mission data from a down link.
- **Generation level 0 file**: generates level 0 file for each segment.

In case of playback mode, KOMPSAT-2 may send several pass to ground station at once. Therefore, the software for producing level 0 have to separate each mission data, namely segment. It separates segments from down link data using line number and ancillary data.

The encryption algorithm used in KOMPSAT-2 on-board processing is easier to process parallel than other algorithms. Parallelizing deciphering is useful to reduce processing time. Single Instruction Multiple Data (SIMD) instructions of Pentium processor are used for

parallel processing to achieve high-speed deciphering. By implementing 8 WAY processing, we achieved 6times faster processing speed than conventional deciphering.

4. Performance analysis

We developed the software for producing level 0 producing using Visual C++ 6.0 at PC with Pentium 3 Dual CPU (650Mbps).

We measured performance of software producing level 0 product. The result of experiment is that processing speed of the software is about 32Mbps. The processing time of R/S decoding held two thirds of entire processing time. The deciphering and file I/O occupied most of the rest processing.

5. Conclusion and Future work

In this paper, we suggested level 0 product specification. While developing ground receiving system, definition of level 0 products was demanded. The key factor used while defining the level 0 products is the efficiency of whole ground receiving system.

This paper also described steps to generate level 0 product and performance of the software. The decryption algorithm used SIMD technique to reduce processing time.

We did not have perfect simulated down link data. So, we could not check that level 0 products generated are valid on separating segment. As soon as we take new simulated data, we will verify that.

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