Introduction of Common Product Platform 6 (CPP6)

Technical White Paper

With the introduction of the first 4K ultra HD security surveillance camera, Bosch Security Systems also introduces its newest Common Product Platform: CPP6. This platform provides ample processing power for high fps Multi Mega Pixel (MMP) image capture and more advanced Intelligent Video Analysis (IVA). CPP6 brings imaging to the next level as it supports the new 4K ultra HD standard and provides additional processing power for smarter imaging algorithms to improve Content Based Imaging Technology (CBIT), dynamic range, video analytics, dewarping, etc.

What is a common product platform?

To guarantee high quality imaging through the entire range of products, Bosch Security Systems uses a Common Product Platform (CPP). A CPP is a reference design that serves as a solid base for future cameras. Based on the same CPP, sub- or new products can be generated more easily by using a different sensor and/or a different housing. Each product cannot only benefit from the features provided by the platform but can also advance its functionality. Other advantages are easier integration with 3rd party security system components, such as VMS and recording solutions. It allows installers and integrators to use the same interface that supports the entire Bosch product portfolio. New camera and software releases, regardless of the price segment, can be easily added to an existing security surveillance system. The implementation effort is balanced for the full product range from IP2000 to IP9000.

A typical CPP at Bosch Security Systems has an integrated system-on-a-chip (SoC) platform supplemented with a Field-programmable gate array (FPGA) for IVA-enabled cameras. Together with the sensor, this is the key internal hardware of a security camera. The first CPP that was broadly exploited in cameras was CPP3, introduced in 2008 / 2009. CPP3 is the first platform with H.264 encoder and HD capability. The NBC-225/255/265, NDN-498/921 and VG5 700/800 run on CPP3. As technology develops, new CPPs are introduced to ensure that new cameras take advantage of the latest technology. Each new CPP extends and improves the previous CPP while still assuring that products from different CPPs can be used jointly in one system. It is optimized for product ranging from mainstream IP cameras to high-performance systems with the latest and greatest sensors and advanced video analytics.

Fig. 1: Schematic of a Common Product Platform

Development from CPP4 to the newest platform CPP6

CPP4 was introduced in August 2011 and was the first full HD platform optimized for the complete Bosch Security Systems product portfolio from IP2000 to IP9000 products. It integrated a low latency image pipeline, multi-streaming H.264 with digital PTZ functionality. H.264 provides superb compression to ensure high-quality video at a much lower bitrates and longer recording time on similar recording hardware. This saves money as an existing network can support more cameras, better video...
quality, or both. CPP4 also brought better 3D noise reduction to support intelligent Dynamic Noise Reduction (iDNR) and it supports automatic exposure to bring intelligent Auto Exposure (iAE) into the 7000 range cameras with IVA capability. At the time of introduction, it pushed the performance boundary and introduced a platform for innovative high-end IP cameras.

As CPP5 is an encoder only platform, CPP6 is the newest camera platform at Bosch Security Systems. CPP6 doubles the encoding performance, it brings higher resolution at high frame rates, it takes CBIT to the next level with smarter imaging algorithms, and it offers potential for more advanced IVA functionality. It uses a state-of-the-art SoC with a 4K (3840x2160p30) H.264 codec engine and up to 32 Mpixels resolution. Its H.264 codec engine pushes for even lower bitrates and implements bidirectional prediction (B-frames) with up to three reference frames. Its SoC also implements progressive refresh (Instantaneous Decoder Refresh (IDR)) for low latency operation; even lower than CPP4. This minimizes the response time from security personnel. Additionally, CPP6 provides flexible multi-streaming that allows on-the-fly changes of resolution, quality and frame rate to deliver a combination of MJPEG and multiple H.264 streams. The user can select an arbitrary combination of frame rate and resolution up to total encoding performance of 250 Mpixels/s.

Some examples:
- One stream at 4K at 30fps
  \[ (1 \times 3840 \times 2160 \times 30) = 249 \text{ MPixels/s} \]
- Eight streams at 1080p15
  \[ (8 \times 1080 \times 1920 \times 15) = 249 \text{ MPixels/s} \]
- Three streams at 5MP30, 1080p15, 720p60
  \[ (2592 \times 1944 \times 30) + 1080 \times 1920 \times 15 + 720 \times 1280 \times 60 = 238 \text{ MPixels/s} \]
- Five streams at 1080p60, 1080p30, 720p30, D1, CIF
  \[ (1080 \times 1920 \times 60) + 1080 \times 1920 \times 30 + 720 \times 1280 \times 30 + 486 \times 720 \times 30 + 352 \times 288 \times 30 = 228 \text{ MPixels/s} \]

Furthermore, CPP6 has a 608 MPixels/s image processing and brings smarter imaging algorithms to improve and expand Content Based Imaging Technology (CBIT) features such as iDNR and iAE. CBIT reduces bitrates and radically improves image quality in all lighting conditions and automatically identifies areas for enhanced processing. CPP6 can do this at a higher resolution (supporting the new UHD format) and over a wider dynamic range. It is also supported with 3D motion-compensated noise reduction to improve iDNR performance. This enables the Bosch camera to always provide the highest quality of IP video images while reducing bitrates to a level where some competitors can only provide full HD imaging. The advanced image pipeline also provides advanced sharpening, chromatic aberration correction, and better tone mapping.

Additionally, since the image processing capability is higher than the encoding capability (608 MP/s vs. 250 MP/s), CPP6 allows for digital oversampling for even better image performance. Digital oversampling is possible when the sensor width or height is bigger than the encoder width or height. A Color Field Array (CFA) pre-scaler in the image pipeline down-samples the image to a smaller resolution (e.g. 1080p) to ensure availability of processing resources. This enables better image performance, e.g. finer picture on encoder resolution, better SNR, higher sensitivity or wider dynamic range.

The platform has such a sophisticated capability, that it leaves room for even higher potential in later product releases. For example, it has electronic image stabilization capability with rolling shutter compensation. Moreover, CPP6 has multi-exposure Wide Dynamic Range (WDR) processing and per-pixel local exposure dynamic range enhancement. Also, special processing is being worked on to support even higher sensitivity of the camera.

### Table: CPP4 vs CPP6

<table>
<thead>
<tr>
<th>Feature</th>
<th>CPP4</th>
<th>CPP6</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>Single core</td>
<td>Dual core</td>
</tr>
<tr>
<td>Encode type</td>
<td>H.264 / MJPEG</td>
<td>H.264 / MJPEG</td>
</tr>
<tr>
<td>Encoder performance</td>
<td>720p60 or 1080p30</td>
<td>1080p120 or 2160p30</td>
</tr>
<tr>
<td>(73 Mpixels/s)</td>
<td>(250 MPixels/s)</td>
<td></td>
</tr>
<tr>
<td>Max. resolution</td>
<td>14MP</td>
<td>32MP</td>
</tr>
<tr>
<td>Max. frame rate</td>
<td>60 fps</td>
<td>120 fps</td>
</tr>
<tr>
<td>Image processing</td>
<td>240 Mpixels/s</td>
<td>608 Mixels/s</td>
</tr>
<tr>
<td>Noise reduction</td>
<td>3D</td>
<td>3D motion compensated</td>
</tr>
<tr>
<td>HDR</td>
<td>Dual exposure</td>
<td>Triple exposure</td>
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<tr>
<td>Image stabilization</td>
<td>-</td>
<td>yes</td>
</tr>
<tr>
<td>Multi-streaming</td>
<td>Up to 4</td>
<td>Up to 8</td>
</tr>
<tr>
<td>Dewarping</td>
<td>-</td>
<td>yes</td>
</tr>
<tr>
<td>Video analytics</td>
<td>Motion+</td>
<td>Motion+, people counting and face detection</td>
</tr>
</tbody>
</table>

Fig. 2: Advancements on CPP6 compared to CPP4
For smarter motion detection, the SoC used in CPP6 provides hardware acceleration for up to 1GHz analytics processing to improve motion+ features. On top of that, cameras with IVA functionality also have an integrated FPGA for more advanced IVA such as people counting, face tracking, motion vector statistics, and a learning mechanism. CPP6 enables IVA to run on a higher resolution and with higher intelligence.

The DINION IP starlight 8000 MP and DINION IP ultra 8000 MP are the first two camera families that run on CPP6. These cameras are released with the first firmware version that supports CPP6: FW 5.91. Additionally, the CPP6 range of products will be extended at the end of 2014 with the new FLEXIDOME IP panoramic 7000 MP. This camera will use fisheye lens distortion correction (dewarping) and barrel distortion correction that is built into CPP6. It has a warp engine for 180°/360° fish-eye lens with multiple area PTZ output.

Sensor to support high megapixel and 4K UHD imaging
For CPP4, the most critical sensor performance criteria were sensitivity, noise and dynamic range. For CPP6, resolution is now also a key criterion. What matters for high quality MMP and UHD imaging is the sensor size. In general, bigger is better. So the sensor size determines how much light is collected to create an image. A bigger sensor also gives more detailed images as it increases the resolution of the camera. The trend in optical format for such cameras tends towards 1/2" size. CPP6 is optimised for bigger sensors.

With higher image processing capabilities than CPP4, CPP6 can process a high density of pixels/s and therefore allows for higher performance sensors to be used. The DINION IP ultra 8000 MP uses a 1/2.3" CMOS sensor with a maximum resolution of 12MP. The DINION IP starlight 8000 MP uses a 1/2" CMOS sensor with a maximum resolution of 5.5MP. These sensors are a perfect fit with high megapixel and ultra HD security, as the CMOS sensor technology is maturing and performance already exceeds CCD technology.

The sensor used for the DINION IP starlight 8000 MP provides three advantages for security cameras: (1) high resolution, (2) excellent sensitivity, and (3) wide dynamic range. The low noise sensor provides a maximum resolution of 5MP (available in 4:3 and 16:9 resolution). It is a Day/Night camera, and the sensor has a back-illuminated structure to allow the camera to provide useable images even at extreme low-light level and at an outstanding wide dynamic range. Enhanced dynamic range processing is established by the ration between the saturation level of signal and random noise in dark. It gives clear and crisp images in light and dark areas even for objects with high contrast.

The DINION IP ultra 8000 MP is the first full UHD security camera in this price segment. The highly sensitive sensor has a back-illuminated structure to always provide a useable image. 12MP (4:3 aspect ratio) and 4K UHD resolution (16:9) is supported and the sensor also features low noise. The camera can also provide a downscaled 1080p image to benefit a wider dynamic range and improved sensitivity. It provides a single-exposure dynamic range that is on a par with the dual-exposure DINION dynamic cameras. Together with CPP6, the CMOS sensor is the best fit for the next generation 4K UHD resolution security surveillance camera. The same sensor will be used for the FLEXIDOME IP panoramic 7000 MP.

Conclusion
CPP6 will bring IP security systems to the next level with numerous benefits. It is optimized for products ranging from mainstream IP cameras to high-performance cameras in the new 4K ultra HD standard. Compared to previous platforms, CPP6 offers much higher resolution, highest frame rates for MP cameras in the industry, and highly usable images even in lowlight and WDR scenes. And yet

Fig. 3: First CPP6 cameras: DINION IP starlight 8000 MP and DINION IP ultra 8000 MP
the platform is bandwidth efficient due to the sophisticated H.264 engine and intelligent Dynamic Noise Reduction. This ensures that the bitrates and thus storage costs are reduced up to 50%. Because the DINION IP ultra 8000 MP is the first UHD camera in this price segment, more details and better imaging are now in an affordable price class. This camera offers much higher resolution at the same frame rates, while low light and HDR performance are the same as that of the higher end HD cameras.