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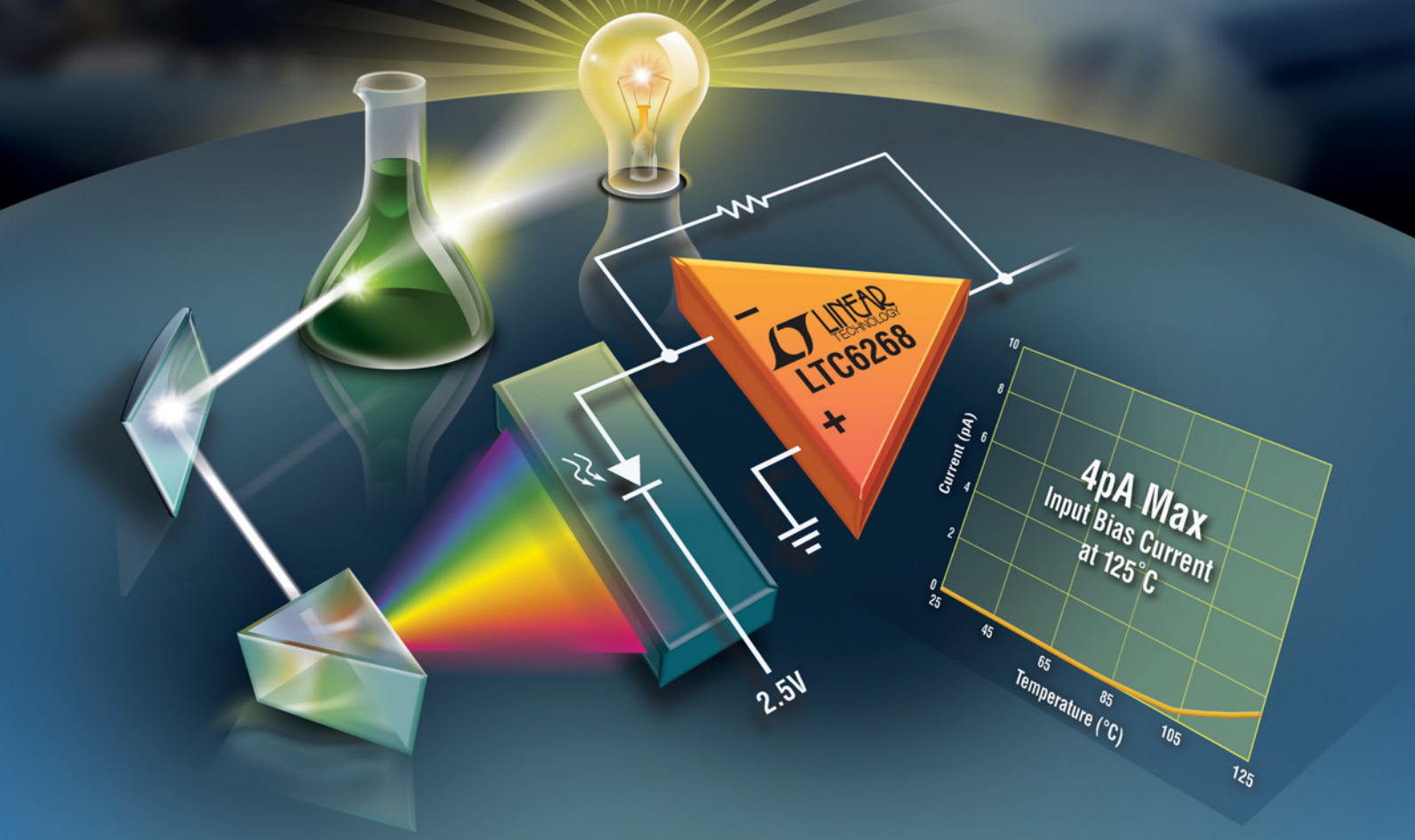
New Amplifiers Enable High Performance in Wide Range Photodiode Circuits

by Linear Technology



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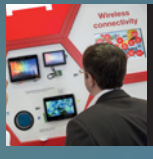

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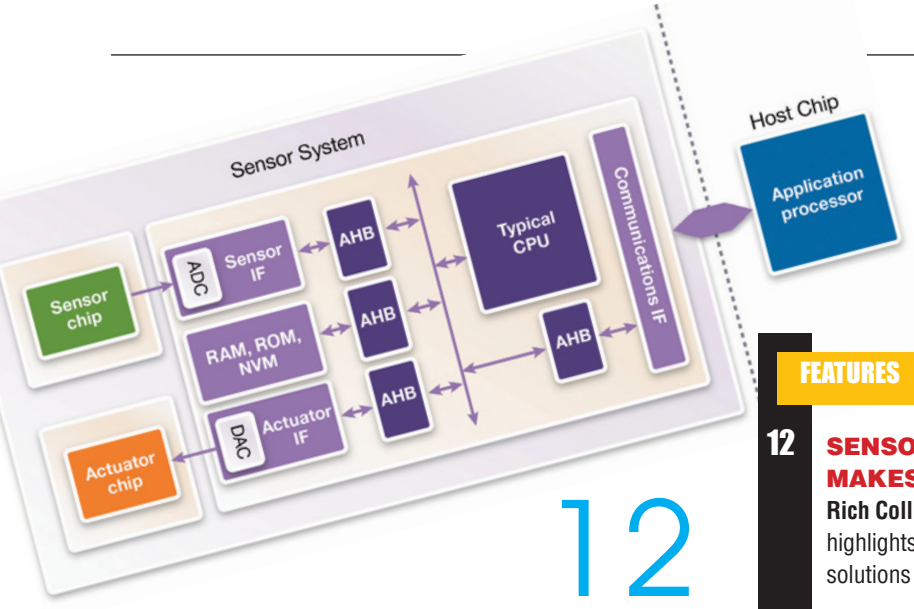

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ELECTRONIC ENGINEERING GRADUATES: WHY THE INDUSTRY NEEDS YOU

> Companies in the [tech] sector are now beginning to see graduates as more than an available source of comparably cheap labour

Seldom does a day go by without somebody somewhere lamenting the lack of skills among the post-graduate community, and nowhere is that more true than in technology. With its rapid growth, boundless opportunities and highly specific skill requirements, the technology sector is one of the biggest consumers of graduate talent, and the level of demand for highly developed skills in this area means that those on the supply side stand to win big.

However, this issue isn't just about skills, there is also a mismatch of perception between the roles that companies hope to fill and the actual skills graduates may bring to the table. In fact, computer science students topped the list of unemployed graduates last year.

The reason for the divide is largely that the skills the industry needs are not graduate-level skills, but professional skills, forged in a business environment. For those employers not willing to compromise and unable to see the potential in the recently graduated, the gap is often viewed as too great.

Historically, the result has been that the technology industry has failed to open up its graduate opportunities widely enough and therefore missed out on this important resource. But companies in the sector are now beginning to see graduates as more than an available source of comparatively cheap labour. In reality, those firms which invest in their graduate workforce gain a lot more than access rights to a valuable future labour resource.

Here is a sample of some of the other benefits that recruiting high-calibre graduates into a company can bring:

• Fresh perspective

Graduates bring fresh ideas, enthusiasm and creativity which can complement the experience and expertise of the more senior team members. These new approaches can often transform businesses that may otherwise be stuck in legacy ways of thinking. The additional advantage of this corporate innocence is that graduates – when properly encouraged – will view everyday systems and processes for what they are and, rather than submitting to their familiarity, can pick out the flaws and inefficiencies invisible to those who work with them year-in, year-out.

• Frame of mind

Recent graduates tend to be very ambitious and keen to prove themselves. In addition, those who enter the workforce straight after university are still in the 'university' frame of mind, which means studying and learning at a rapid rate. As a result, they are often able to pick up new information quickly, without previously ingrained ways of working.

• Recruitment

An added bonus of recruiting graduates is the opportunity to gain access to their pool of friends. It's commonplace for employees to refer friends with the particular skills the company needs, another effective way of securing new talent. In addition, new graduates tend to be far less experienced in the 'tips and tricks' of interviews, giving a much clearer window into their mind and abilities than might be available from seasoned employees. This allows employers to grasp much more accurately the future potential a worker can bring to the company.

Despite the benefits, companies have been slow to open their doors to fresh-faced, inexperienced graduates, even in the technology sector. However, there is good news on the horizon; according to the Association of Graduate Recruiters (AGR), the number of graduate vacancies is set to rise by 10.2% during 2014. This is great news for the overall economy and the technology industry in particular, which is seen as a big growth sector for graduate recruitment. With the downturn left firmly in the past, the growing economy will offer great opportunities.

By Richard Acreman, CEO of technology services company WM360 (www.wm360.com)

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TECHNOLOGY HUB IS AT THE HEART OF MANY REVOLUTIONARY IDEAS IN THE INDUSTRY

Freescale Semiconductor has celebrated the first year of its Discovery Lab, a technology incubator pursuing high-risk, high-reward ideas. Based in Austin, Texas, at the company's headquarters in Oak Hill, the lab brings together Freescale's best minds from across the company and around the globe to test and prove unique ideas for significant improvements of existing technologies and techniques.

Inventors at the Lab explore alternative materials, create cutting-edge packaging technologies and new systems, enabling next generations of products to fuel major market trends, such as the IoT (Internet of Things), SDN (Software Defined Networks) and ADAS (Advanced Driver Assistance Systems).

Every employee is encouraged to submit ideas, which are then assigned to that employee to work full time on their realisation. Since its opening, over 200 ideas have been submitted and more than 20 employees are currently working on nine projects. The Freescale Discovery Lab has forged partnerships with numerous universities, and the opening of a second lab in Toulouse, France, (pictured) took place in September.

In September 2014, Freescale opened a new technology hub in Europe, situated in Toulouse, France

"We couldn't be more proud of what the Freescale Discovery Lab has accomplished in such a short time," said Gregg Lowe, Freescale president and CEO. "These labs will continue to be a haven for disruptive innovation that nurtures new ideas, bringing about dramatic improvements in technology that change the face of our industry."

David Kramer, director of Freescale Discovery Lab, added: "It's incredibly rewarding to witness the types of game-changing ideas that can lead to new products that dramatically improve what exists, or even create entirely new markets right from within the [company] walls and from the minds of our employees."

Freescale has a history of innovation and has played a significant role in the evolution of embedded technologies. It delivered the first automotive microcontroller designed to improve fuel efficiency and control emissions and it helped transmit the first words from the Moon with its radio frequency (RF) technology.

"Freescale has always been about challenging the status quo in our industry and continually proving these never-before-seen concepts," said Kramer.

ZIGBEE HAS BEEN UPDATED FOR RF-BASED REMOTE CONTROLS

The ZigBee Alliance, a global ecosystem of organizations creating wireless solutions for use in energy management, commercial and consumer applications, announced the ratification of the ZigBee Remote Control 2.0 standard. The new standard provides consumers with the capability to directly control all devices in a home with one remote control, including a "Find My Remote" feature.

"With this release, which includes a range of necessary enhancements, ZigBee is now the most comprehensive standard for optimal control experience," said Arsham Hatambeiki, Vice President of Corporate Product Strategy at Universal Electronics. "The native support for an application capable of automatic discovery and configuration of an entertainment system, finally allows for a hassle-free control experience and addresses the most essential needs of the consumer."

All parts of a ZigBee smart-home network including lights, heating, air conditioning, security and home monitoring can be operated with the same remote control. The standard also enables telecom companies and cable operators to seamlessly integrate their smart-home offerings with set-top boxes.

Major contributions to the standard's implementation have come from Freescale, GreenPeak Technologies, NXP, Silicon Labs and Texas Instruments. It is now available for product development and it's free, available for download from the Alliance's website.

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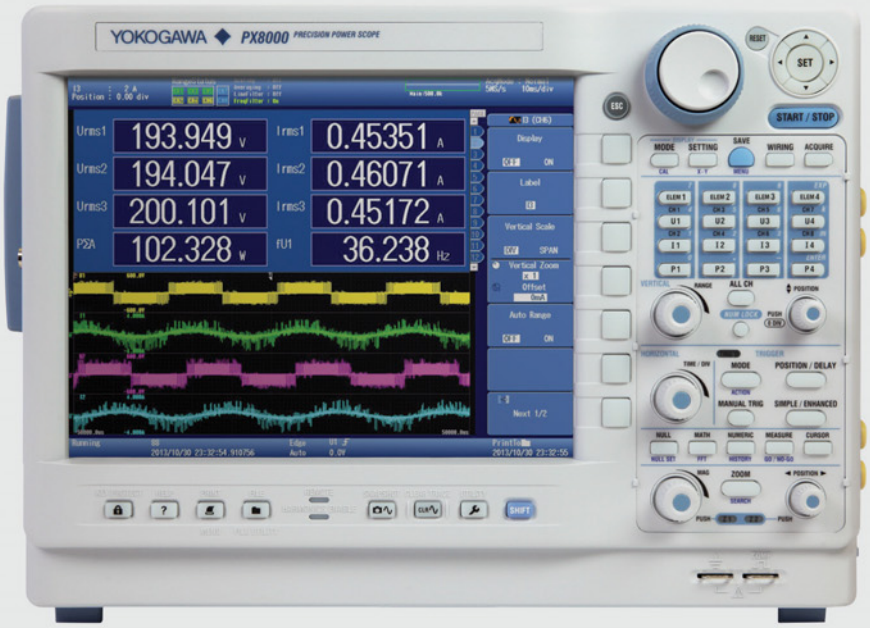

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Precision Making

NEW AMPLIFIERS ENABLE HIGH PERFORMANCE IN WIDE RANGE PHOTODIODE CIRCUITS

By Brian Black, Product Marketing Manager, and Glen Brisebois, Senior Applications Engineer, Linear Technology Corporation

Photodiodes transform light into a current or voltage which can then be used in electronic circuits in applications ranging from solar cells to optical data networks, from precision instruments to chromatography to medical imaging. What all these applications have in common is the need for circuitry to buffer and scale the photodiode output. For applications requiring high speed and high dynamic range, transimpedance amplifier (TIA) circuits like the one shown in Figure 1 are often used. In this figure, the feedback capacitance is shown as a parasitic capacitance. In many applications this will be a deliberately placed capacitor to ensure stability.

This circuit has the photodiode in "photoconductive mode" with a bias voltage applied to the cathode. The virtual connection between the two op amp inputs holds the anode at ground, thus applying a constant reverse bias voltage across the photodiode. A photodiode can be thought of as a current source (proportional to light intensity), a capacitor, a large resistor, and a so-called dark current (the small current when no photons are present) all connected in parallel. The larger the bias voltage across the diode, the smaller the photodiode capacitance tends to become. While this is good for speed, it is limited practically by the capability of a photodiode to withstand large reverse voltages.

The current generated by the photodiode (I_{PD}) is amplified by the TIA circuit and converted to an output voltage through the transimpedance gain resistor (also referred to here as the feedback resistor, or R_F). Ideally this current flows through R_F (i.e., $I_{FB} = I_{PD}$), but in practice the amplifier introduces an error current in the form of op amp input bias current. This bias current results in an error voltage at the output and limits dynamic range. The larger the gain resistor, the greater this effect. It is important to select an amplifier with sufficiently low bias current (as well as input offset voltage and input offset voltage drift) to achieve the required dynamic range and overall accuracy.

> The current generated by the photodiode (I_{PD}) is amplified by the TIA circuit and converted to an output voltage through the transimpedance gain resistor

One other consideration is the effect of op amp input current variation over temperature. Op amps with bipolar input stages have fairly constant input current, but this current is so high even at room temperature (nA or even µA) that unbuffered bipolar amplifiers are not suitable for many high transimpedance gain applications. For this reason, op amps with a FET input stage are often preferred over bipolar amplifiers because they have inherently lower input current – often in the single digit picoampere range or even lower at room temperature. But input ESD protection diodes leak as they get hot, causing the input current to rise exponentially with temperature. It is not unusual for an op amp with picoampere bias current at room temperature to have nanoampere input current at 125°C. One alternative is to use a discrete FET to buffer the photodiode at the amplifier input, but this requires an additional component and the associated board space and has relatively high input capacitance. Another option is to use the new LTC6268 femptoamp bias current op amp, which has input bias current of just 3fA typical at 25°C. It uses replicas of the input voltages fed into split ESD diodes to effectively bootstrap them and keep the voltage and current across the diodes extremely low during normal operation. Typical input current performance is shown in Figure 2. While this current still increases over temperature, it is orders of magnitude lower than that of other amplifiers. Guaranteed maximum input current is 0.9pA at 85°C and 4pA at 125°C. The pinout of the LTC6268 was carefully chosen to help minimize board leakage currents, which can contribute to measurement error.

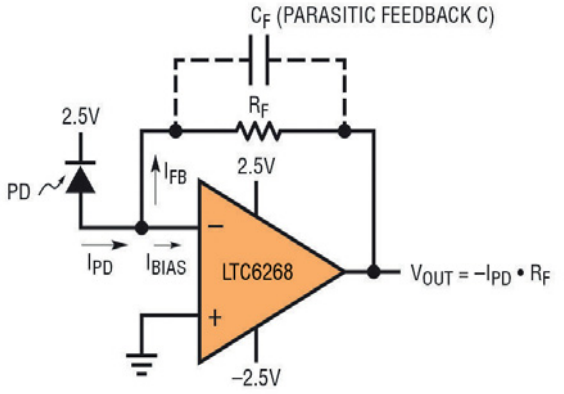

Figure 1: Transimpedance Amplifier

At the femtoamp level, unexpected leakage sources can come from adjacent signals on the circuit board, both on the same layer and from internal layers, any form of contamination on the board from the assembly process or the environment, other components on the signal path, and even the plastic of the device package. The LTC6268 is available in SOT-23 and SOIC packages. Although the SOT-23 version has a smaller footprint for a board space advantage, the SOIC is the best choice for low input bias current applications. For this package, pin spacing is wider and V- is moved to the other side of the package, away from the inputs. Also, pins 1 and 4, next to the inputs,

are left unconnected to facilitate guard ring routing. This is especially useful for applications that experience electrically noisy environments. For more information on using methods such as guard rings to protect against leakage currents, see pages 17 and 18 of the LTC6268 data sheet.

Since dynamic range is the ratio of maximum output signal to noise, it is also important to select an op amp with sufficiently low noise. Op amp current noise and voltage noise both matter, in varying degrees depending on the value of R_F and C_{IN}. The input capacitance, C_{IN} (see Figure 3), is a combination of the photodiode capacitance, the amplifier input capacitance, and stray board capacitances. In transimpedance amplifier circuits, the current noise is multiplied by R_F, causing noise to appear as an output voltage error. Also, the amplifier's voltage noise is multiplied by the noise gain. So for higher R_F values, current noise (i_n) becomes more dominant, and for circuits with high C_{IN}, voltage noise (e_n) dominates. Finding an op amp with both low current noise and low voltage noise is challenging. The input-referred voltage and current noise of the LTC6268 is 4.3nV/√Hz at 1MHz and 5.5fA/√Hz at 100kHz, respectively, striking a good balance between the two.

Input capacitance also limits bandwidth. One way to think about this is to consider the impedance of the input capacitor as the gain resistor (R_G) in a conventional inverting op amp configuration. The larger the capacitor, the smaller the impedance and the larger the effective gain the op amp "sees" ($1+R_F/R_G$), often called the noise gain. Since an amplifier's bandwidth is inversely proportional to gain due to the constant nature of the gain-bandwidth product, this means that a large input capacitance limits the circuit bandwidth. This can also be thought of in terms of stability. Capacitance at an op amp input can create a pole in the frequency domain or a lag in the time domain. This pole can be compensated to make the circuit stable by adding a (deliberate, rather than parasitic) feedback capacitor (C_F). The larger this capacitance, the more limited the circuit bandwidth. Thus it is important to choose an amplifier with low input capacitance and to carefully lay out the board to avoid stray input capacitance and feedback capacitance. See pages 14 and 15 of the LTC6268 data sheet for some practical ideas for reducing stray feedback capacitance which in practice achieves greater than 4x improvement in circuit bandwidth. With just 0.45pF input capacitance, the LTC6268 contributes only a small portion of the total circuit capacitance, preserving high bandwidth.

The LTC6268 is a good example of an amplifier optimized for the performance required by high speed, high dynamic range photodiode circuits described in this article. The LTC6268 offers 500MHz gain bandwidth, enabling the single-stage circuits shown in the LTC6268 data sheet from 20kΩ transimpedance gain with 65MHz bandwidth to 499kΩ transimpedance gain with 11.2MHz bandwidth. Also, the LTC6268 has wide bandwidth, low distortion, and high slew rate, making it suitable for high speed digitizing applications such as is shown on the last page of the LTC6268 data sheet. Its very high impedance makes it ideal for buffering high impedance or capacitive sources. A dual channel version LTC6269 is also available. Versions with individual shutdown pins reduce current consumption when amplifiers are not in use and make them suitable for multiplexed applications.

Although hundreds, if not thousands, of op amps are available on the market, finding a suitable transimpedance amp for high speed, high dynamic range photodiode circuits is remarkably challenging. Each requires its own unique set of performance characteristics, including extremely low input bias current and input current temperature drift, high speed (e.g., gain bandwidth product and slew rate), the right balance of low voltage and current noise, and low input capacitance. Special attention should also be given to board layout to minimize leakage currents and stray capacitances, which would limit the accuracy and speed of the circuit. The LTC6268 represents a new class of op amps, precisely optimized for exactly these high performance TIA applications.

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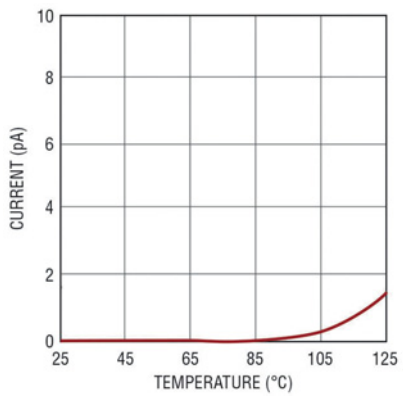

Figure 2: LTC6268 input bias current remains low over temperature

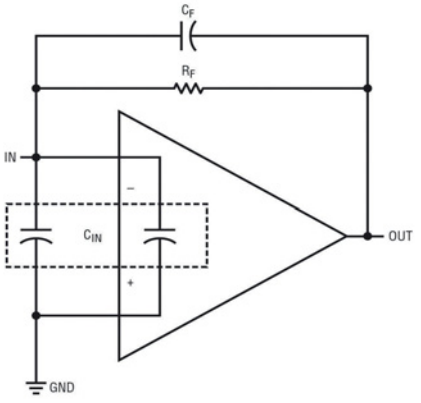

Figure 3: Input capacitance includes sensor, board, and amplifier capacitance

Prescribed By The Patient

MYK DORMER IS A SENIOR RF DESIGN ENGINEER AT RADIOMETRIX LTD **WWW.RADIOMETRIX.COM**

Imagine a world where, instead of a doctor prescribing a treatment based on the patient's symptoms, the medically untrained patient would tell the doctor which drug to prescribe, but would then still expect the doctor to effect a cure using it.

While this humorous musing is quite deliberately absurd, I am beginning to see something analogous occurring within the sphere of low-power wireless design. Traditionally, a customer has either outlined a radio specification (range, acceptable price, size, power consumption, data rate and so on) so that the sales or engineering staff can choose the correct product or suggest a custom solution, or they have browsed the technical literature and data sheets in order to make that decision themselves. While these approaches have their limitations – mostly related to incomplete specifications or poor understanding of the technologies involved – for the most part a usable solution can be found with an acceptable amount of effort.

Unfortunately I am beginning to see a change for the worse in this process. As the ongoing development of integrated radio devices advances – and as those devices are more and more widely advertised and promoted – there is a perception that a radio design is no longer a complex interaction of specialist components, but has become a simple "building block" assembly task.

Such perceptions are not, I hasten to add, held by anyone intimately involved in using the new RF silicon. While actual on-the-PCB circuit design becomes less central, configuration and programming and hence the in-depth understanding of what you are configuring become far more vital, while the traditional hardware PCB layout and post-design testing and qualification tasks have – if anything – become more complex and exacting.

The place where the "building block" mentality has taken hold however is in the minds of non-technically skilled managers and purchasers. Here there is the perception that, because "silicon vendor A" is releasing its wonderful new next generation device and because its generic claims are grandiose and the advertisement very striking, then that is the only device to use. This, in turn, leads to top-down project plans and initial customer enquiries that start not with a functional specification but with a bold instruction that the radio is to use "the all new XX1234 chip from manufacturer A".

"The place where the "building block" mentality has taken hold is in the minds of non-technically skilled managers and purchasers

Such a specification is as ludicrous as the fictitious medical example I mentioned earlier – and, yet, I have been presented with this sort of "instruction" on numerous occasions. It is the technical equivalent to visiting a travel agent to arrange a holiday and stipulating that all journeys must be conducted by rickshaw, or by spaceship.

On a practical level, specifying by "named component" instead of by a level of performance or a critical parameter (while inadvisable for a number of in-depth technical reasons) fails at a very obvious, human level: it bypasses (indeed, it discards, with possibly catastrophic consequences for your project) the detailed specialist knowledge of your engineering department or your wireless module supplier and replaces it with nothing more than an uninformed "gut feeling" decision. This might not be so bad, except that you, as the eventual user, is already paying for that "technical knowledge" in very real terms, in the salaries of your engineers, or the unit prices of the RF sub-assemblies you buy. By over-riding the proper design process, you are throwing that money away. At worst, the mandated choice of component could be so unsuitable that your entire project simply fails irrevocably; at best, the part may prove usable, but will incur heavy learning-curve costs and may well not result in as good a solution as a "free hand" design could achieve.

In any case, in a competitive market no-one can afford this level of inefficiency. You are already employing skilled engineers, either directly, or indirectly. Let them use those skills. ●

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SENSORS ARE UBIQUITOUS – FUSION MAKES THEM MORE USEFUL

RICH COLLINS, ARC SEGMENT MARKETING MANAGER AT SYNOPSYS, HIGHLIGHTS SOME SENSOR FUSION APPLICATIONS AND THE NEED FOR IP SOLUTIONS TO SUPPORT THEM

Although a novelty a few years ago, sensors applications are much more prevalent now due to the explosion in smart devices. Reading and interpreting environmental conditions such as pressure, temperature and proximity are part of many systems nowadays. Today, more sophisticated sensor applications combine multiple sources of sensor data to provide higher order functionality, a concept called sensor fusion. Combining an accelerometer, gyroscope and magnetometer (compass) to create an accurate motion sensor is a prime example of the fusion concept.

Increasing complexity of sensor fusion algorithms requires additional processing capability and software overhead. To reduce impact on the applications processor, sensor functions are being handled by off-chip co-processors as well as integrated, on-chip subsystems.

The Market Growth of Sensor Fusion

There has been significant growth in systems incorporating sensor fusion technology as more semiconductor suppliers integrate sensor interfaces into their system-on-chip (SoCs) devices. Although motion sensing in smartphones is the most common example of sensor fusion implementation, these features are being incorporated in dozens of different applications found in automotive, consumer electronics and digital home markets. According to Semico Research (see Figure 1), the number of systems incorporating sensor fusion will grow from 400 million units in 2012 to over 2.5 billion units in 2016 – an annual growth rate of almost 60%.

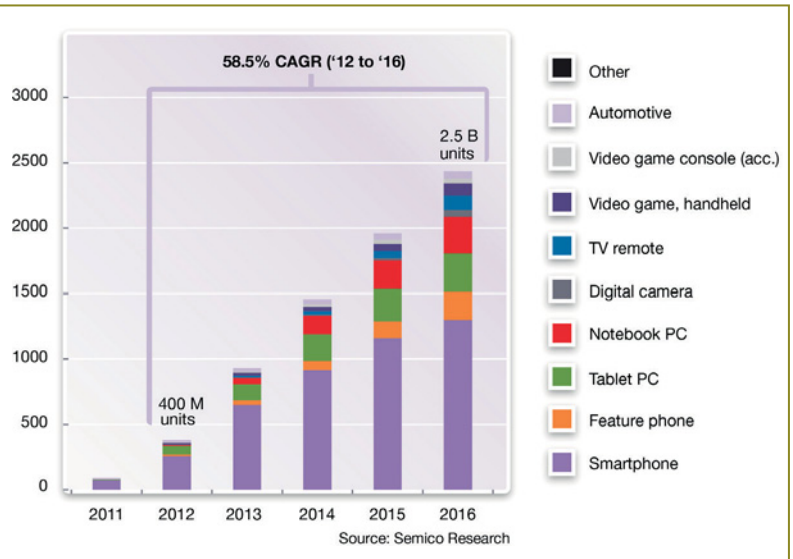

Figure 1: Sensor fusion systems are predicted to grow to 2.5 billion units by 2016

Everyday Fusion

Wearable devices are becoming extremely popular as people's interest in tracking their personal health and fitness levels grows. From measuring heart rate and sleep patterns, to tracking numbers of steps and advanced workout monitoring, the scope of personal activities logged by users with wearable devices is astronomical. Tens of millions of these products are sold annually, and the number of these types of devices shipped is estimated to reach 300 million annually, according to the report *"Global Wearable Device Unit Shipments"* by BI Intelligence.

Today's wearable devices mostly calculate one-dimensional measurements, such as counting calories or miles run. By combining multiple sensors together – a.k.a sensor fusion, a much more accurate picture of activity can be created and analyzed. Sensor software companies are already busy demonstrating technology that provides data on the angles, velocity and positioning of various body parts – sent in real time to mobile devices. This complex combination of sensor hardware and software algorithms will become a mainstream feature of next-generation wearable devices.

Another interesting advance in sensor fusion relates to location. The concept of creating a geo-fence, or a virtual perimeter, has existed since GPS became mainstream technology. For example, a geo-fence can be dynamically created around a home or business when combined with a location-based device, like a smartphone, to make it useful. When the mobile device enters or leaves the geo-fenced area, a notification may be sent to the device (or elsewhere) indicating the event has occurred. This basic communication concept is now being enhanced to generate specific messaging to targeted mobile devices based on location. For example, geo-

fencing enables a store to know when you have approached a specific department and notifies you of sale items in that section.

Features and applications can be enabled or disabled based on general location. Combining the coarse-grained GPS data with more fine-grained indoor location protocols such as Bluetooth Low Energy (LE) or Near-Field Communication (NFC) allows suppliers to provide a more customized experience for the shopper. This is the basic concept behind Apple's iBeacons and will likely become a standard feature on both iOS and Android devices.

Sensor Integration Trends

In many of today's sensor-based applications, the sensor processing is handled off-chip; that is, the fusion of the sensor data is done on a separate device (often a microcontroller) with an interface (typically SPI or I2C) to the application processor.

Figure 2 shows a typical sensor implementation using discrete components. This example highlights an analog sensor implementation, but digital sensor systems are implemented with similar architectures.

There are good reasons to design sensor implementations this way – especially in the mobile device space. While mobile applications processors pushing on to 28nm and beyond, the sensors ecosystem is several process technologies behind. For example, the sensors themselves may still be manufactured in a 180nm process whereas the microcontrollers managing the sensor data are based on 90nm or 55nm flash-based process technology. Performance is adequate and low cost is critical, so designers have continued to implement discrete devices.

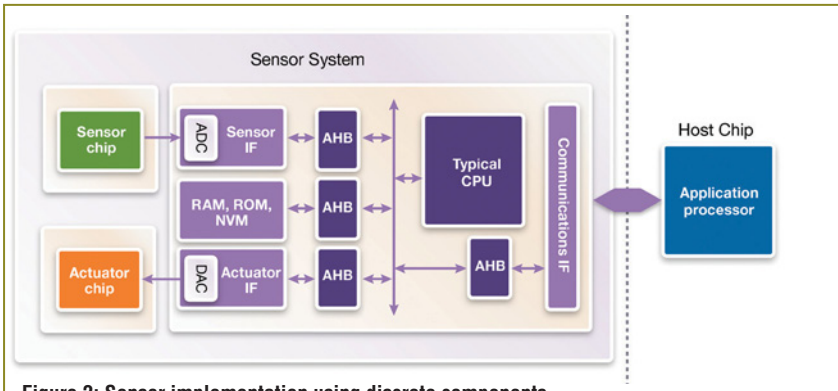

Figure 2: Sensor implementation using discrete components

However, the continuous need to provide smaller, faster, lower-power systems tends to drive more integration into application processors. As geometries shrink, more transistors can be

integrated onto a single die. At some threshold, the area savings and performance boost swing in favour of integrated solutions versus discrete implementations. This trend will ultimately apply to sensor implementations, allowing the sensor logic to act as an on-chip sensor hub, offloading sensor fusion algorithms from the host or applications processor.

Integrated Sensor IP Solutions

Whether integrated on the application processor or on a separate microcontroller, providing dedicated sensor control hardware is integral to many types of systems. When designing these systems, one architectural approach is to integrate standalone IP blocks for sensor control. However, this shifts the burden on to the design team to independently verify and debug this "home-grown" system, which is both time-consuming and susceptible to error.

As these sensor systems become more complex, design teams are increasingly looking for pre-integrated IP subsystems, consisting of pre-verified hardware and software that can be quickly incorporated into a system with less risk, enabling them to focus their efforts on the differentiated portions of the design (see box below). ●

SYNOPSYS DESIGNWARE SENSOR IP SUBSYSTEM

The Synopsys DesignWare Sensor IP Subsystem is optimized to address the need for pre-integrated IP subsystems. The configurable, integrated subsystem consisting of hardware and software efficiently processes both digital and analog sensor data. It features a power- and area-efficient ARC EM4 32-bit processor, which includes custom extensions and instructions supporting application-specific hardware accelerators and tightly integrated peripherals. In addition, the subsystem includes multiple configurable GPIO, SPI and I2C digital interfaces for off-chip sensor connections as well as ARM AMBA AHB/APB protocol system interfaces to ease subsystem integration into a SoC.

The Sensor IP Subsystem also includes dedicated hardware accelerators for signal processing functions such as filtering (FIR, IIR), correlation, matrix/vector operations, decimalization/interpolation and complex mathematical operations. These functions help accelerate sensor application code development, reduce memory footprint and increase sensor fusion performance. Implementation teams can choose between dedicated hardware and the comprehensive software DSP library also provided as part of the Sensor IP Subsystem. This allows designers to make area, power and performance tradeoffs to meet their specific application needs.

By using a fully integrated sensor IP subsystem, design teams can create more efficient sensor-based architectures, which reduce on-chip area, latency and overall energy consumption (Figure 3).

When comparing measured results of cycle count and energy consumption for typical sensor application functions (i.e. scalar math, complex math, vector functions, matrix functions, IIR filters, and FIR filters), the Synopsys Sensor IP Subsystem shows significant improvement compared with discrete solutions using popular commercial embedded processors (Processor A optimized for area, Processor B optimized for performance). Figures 4 and 5 show relative cycle count and energy consumption for each of the three functionally equivalent solutions.

Utilizing the hardware accelerators of the Sensor IP Subsystem to accelerate typical sensor functions results in significant performance improvements (lower cycle counts), which translate into drastically lower energy consumption, either due to the shorter time the application runs (same frequency, higher performance), or the ability to lower the clock frequency (lower frequency and lower power, same elapsed time).

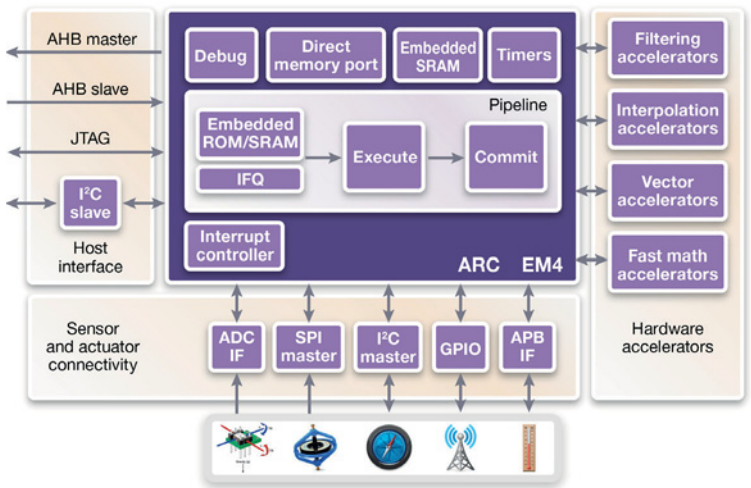

Figure 3: Synopsys Sensor IP Subsystem

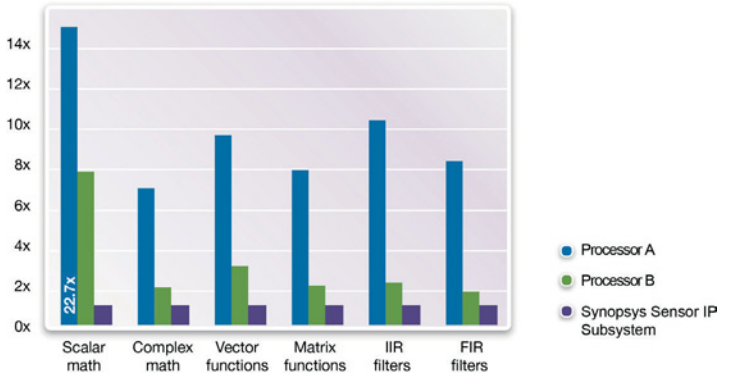

Figure 4: Relative cycle counts compared to Synopsys's solution

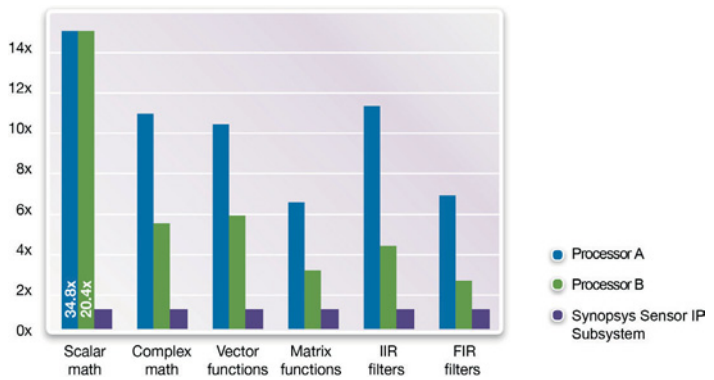

Figure 5: Relative energy consumption compared to Synopsys's solution (40nm)

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HANDLING 'BIG DATA' FROM VIDEO STREAMS

PROFESSOR PLAMEN ANGELOV, CHAIR OF INTELLIGENT SYSTEMS AT LANCASTER UNIVERSITY AND DIRECTOR OF ENTELSENSYS, DISCUSSES PATENTED NEW TECHNOLOGY FOR PREDICTING AND UPDATING THE POSITION OF TARGETS IN VIDEO STREAMS

The technology runs on single-card computers weighing just a few hundred grams, making the system highly portable

Handling 'Big Data' from video streams is a key challenge in computing. The availability of cheap video cameras and the miniaturization of hardware devices such as computer processors and wireless communication devices have brought on a deluge of video data. Video is increasingly used and plays an important part in security and surveillance as well; both private homes and public buildings such as airports, car parks, stores and offices, for perimeter protection and monitoring roads and other transport systems. The UK has more CCTV cameras per capita than anywhere else in the world.

For military and defence organisations the needs are more complex. There is already greater use of a range of sensors that generate images and video, from electro-optical, infrared, signature aperture radars (SAR) to traditional, high-resolution cameras. These are usually airborne or space/satellite based, but can also be ground based, moving vehicle based or handheld. Whatever the area of application, the challenges of 'Big Data' remain.

Managing Raw Data

Vast quantities of video material can be generated very fast and at low cost; the technical challenge is how to analyse and use this raw information without large investments in human resources to monitor and interpret it.

The raw data is in pixel format while the useful, human-understandable information is usually in the form of scene-related features, which requires a higher order of aggregation. For example, two images may have the same resolution in megapixels but different objects of interest. Therefore, transforming autonomously and in real time the low level, pixel-based data streams into meaningful and intelligible information in terms of objects, behaviours, story boards etc, is a difficult challenge without direct human supervision and involvement, especially on portable hardware.

Modern technology can detect moving objects and 'novelties' (objects that may be stationary, but were not there before); it can segment images into regions and objects (e.g. identifying roads, buildings, fields, rivers, railways etc); it can track moving objects; classify objects into predefined classes (e.g. cars, motorbikes, lorries, tanks etc); group objects into clusters; and analyze the behaviour of objects of interest (e.g. lane changes and turns by cars, speeding or acceleration/deceleration, anomaly detection, etc). Analysis, however, still continues to be offline – so, not in real time. The reason is simple: a still image of megapixel resolution is represented by millions or billions of data items (each pixel of a colour image is itself represented by three digits); a video usually has 25 frames per second, making 25 x 3 = 75 times per second. Video footage with a length of just 12s generates billions or trillions of bytes.

A possible solution could be 'parallelization', where a huge task is broken down into smaller elements and dealt with by computers in parallel. However, this demands larger or more powerful – and power hungry – hardware to be used, such as the new Graphics Processing Units (GPUs) being developed by US firm Nvidia, for example.

However, when the requirement is to have a portable device rather than a rack of computers or HPCs (high-performance computers) analyze video in real time, then the challenge is still open. For the moment the challenges are being addressed by offline analysis and human operators to a certain extent (for determining user- and problem-specific parameters, analyzing behaviour and making decisions).

The Aurora Project

In September 2014, Lancaster University demonstrated its latest, world-leading work in the field of analyzing video-based Big Data for the UK's Ministry of Defence, as part of its AURORA project – the development of an unmanned surveillance plane. A system has now been developed,

programmed, debugged and tested with miniaturized hardware in laboratory and field environments that provides real-time analysis and delivers several orders of magnitude faster processing compared with best known research results. The technology provides onboard real-time processing of high resolution (up to full High Definition) video using portable single-card computers, weighing just a few hundred grams each.

Traditional approaches have been based on so-called background subtraction. This relies on modelling the background of a scene per pixel using certain features' (usually but not necessarily) colour space and subtracting the current frame from that model. The so-called foreground is formed by the pixels that differ significantly (usually measured by a user- and problem-specific threshold) from the background model. The background model is built based on a window of consecutive frames (usually the number of frames in a window, N being in the order of dozens), kept in memory and processed in batch mode.

In the Lancaster approach patented in the US we propose the frames be processed in a one-pass manner using recursive calculations. This removes the need to store and process large amount of information. In addition, the proposed approach does not require user- or problem-specific thresholds; this removes subjectivity and reduces the effect of noise as a factor of detection.

The new technology allows for automatic identification of physical objects/targets on the scene that is formed by most of the foreground pixels (some of which usually are a result of noise, movements of leaves of trees, variations in light etc). The proposed method for addressing this problem is also based on the recursive density estimation (RDE) technique, also patented by Lancaster University. Additionally, the Lancaster approach will track the object that was identified previously as it moves in the scene. The objective of the algorithms for visual tracking is to precisely match the target from frame to frame. Generally, the use of colour as a cue is preferable to motion because of computational efficiency and robustness with respect to object geometry and occlusion.

Some previous approaches have only been usable offline; there are online approaches, based on the Kalman filter (KF), but they assume normal Gaussian distributions and a linear model of target movements that is obviously far from the reality.

Our approach is based on an online learning method and fuzzy systems used to predict and update the position of the target in the video stream. The recursive nature of the algorithm made it possible to design an evolving fuzzy rule-base online, which adapts to the variations of the data pattern, also patented.

> When the requirement is to have a portable device rather than a rack of high-performance computers analyze video in real time, then the challenge is still open

Using multi-input-multi-output (MIMO) it is also possible to track multiple targets. This approach is nonlinear overall (although locally, in the feature space it is linear) and applicable to non-stationary data streams. As a result, a completely automatic, real-time approach is proposed for detection, identification and tracking in video streams that is free from user- or problem-specific thresholds and is significantly faster, more precise and more robust than other known alternatives. ●

A view from the onboard, autonomous, real-time traffic analysis system

SATELLITE TRACKING AND DETECTION
OF MILITARY ASSETS AND PERSONNEL

STOJCE DIMOV ILCEV FROM DURBAN UNIVERSITY OF TECHNOLOGY (DUT) IN SOUTH AFRICA WRITES ABOUT SATELLITE TRANSPONDERS CURRENTLY AVAILABLE FOR GLOBAL TRACKING AND DETECTION OF MILITARY ASSETS AND PERSONNEL AT SEA, ON GROUND AND IN THE AIR

New tracking technologies integrate Communication, Navigation and Surveillance (CNS) solutions and services for enhanced traffic control and management of military mobile personnel and assets.

Received tracking data by a GPS/GLONASS receiver (Rx) of military personnel or mobile assets can be sent via the Geostationary Earth Orbit (GEO) or non-GEO spacecraft. All mobiles and personnel require far more sophisticated new Satellite Asset Tracking (SAT) than the standalone GPS or GLONASS positioning systems. As such, a Global Mobile Tracking (GMT) system will be integrated into a SAT device containing GPS or GLONASS receivers and mini GEO and non-GEO satellite transceivers with their antennas. This way, the SAT (using GNSS subsystems of US GPS and Russian GLONASS) can provide free Position, Velocity and Time (PVT) data for military and/or civilian assets – tracking transponders dedicated for civilian application discreetly installed onboard ships or aircraft can provide reliable antipiracy or hijacking solutions. The data is then received by ships, land vehicles and aircraft via onboard GPS/GLONASS Rx, integrated with a satellite transceiver (see Figure 1). These are frequent transmissions via GEO or non-GEO spacecraft via a Ground Earth Station (GES) and the Internet to the supporting control and operations centres.

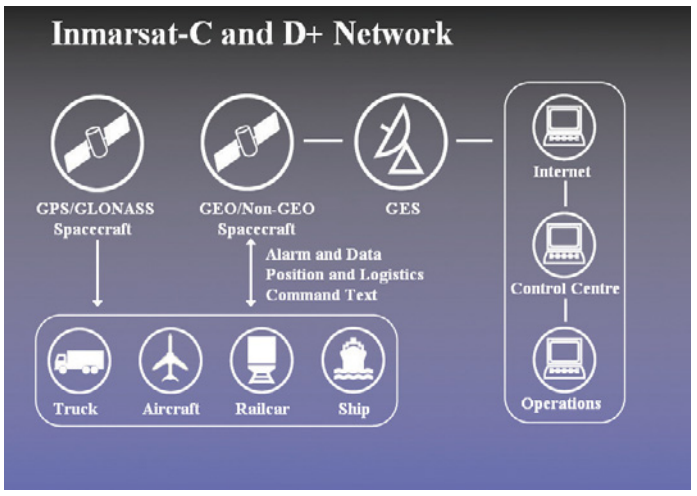

Figure 1: Configuration of the SAT system

Greater Need For Support

There were many incidents in the past when ships and aircraft disappeared in disasters caused by collision or grounding, and due to a lack of right systems were never traced. As such there was a greater need for new tracking and detecting solutions via GMT. For instance, if GMT transponders were fixed to the Air France or Malaysian aircraft that crashed in 2009 and 2014 respectively, Search and Rescue (SAR) forces would have been able to find the wrecks within a day or two, in an area of up to 200 miles.

The way the GMT onboard equipment operates is as follows: it receives GNSS signals from GPS/GLONASS spacecraft (1) and sends PTV tracking messages (2) via a GEO satellite to GES (3) of Satellite Communication and Application Service Providers (Internet) to the Tracking Control Centre (TCC) processor (4), shown in Figure 2. In the figure, all lines highlighted in red are indicating a GMT receiving process.

> Leaders can easily and securely pass critical information such as mission changes, alternate routes and other information essential to the mission to subordinate units in the field

The Axonn SAT terminal is a suitable solution for GMT applications using the Globalstar Big Low Earth Orbit (LEO) satellite network (see Figure 3a). This equipment contains a GPS module, sensor and configuration interface, satellite modem, host processor, GPS receiver (Rx), Globalstar satellite transmitter (Tx) – which only uses the Globalstar network, and a battery.

This SAT unit provides a simplex (one-way) satellite transmission of PTV data and, therefore, will not receive PTV data from the TCC of other mobiles. For that reason the solution can be made with a duplex (two-way) SAT to communicate via the GEO Inmarsat or Big LEO Iridium satellite networks. Figure 3b shows examples of the Axonn SAT small unit.

It is important to mention that Globalstar does provide duplex SAT satellite transmissions.

The fourth mobile operator for SAT applications is Little LEO Orbcomm, a satellite network that provides both, simplex and duplex services.

The Inmarsat and Iridium SAT transponders are the best

solutions for GMT as they provide a full global coverage and the following:

1. The SAT terminals can be installed in each mobile system using an onboard power supply or in emergency situations they may use their own batteries. They can be employed for tracking military personnel.
2. The SAT unit can be pre-programmed for different requirements and to send GPS location and other data at pre-defined intervals. Messages are transmitted via the Inmarsat or Iridium duplex satellite networks through a message-routing infrastructure and then sent to the host (TCC), or can be integrated with a hosted mapping application.

Tracking And Detecting Via Inmarsat

The International Maritime Satellite Organization (Inmarsat) was set up in 1979. It began operating in 1982 using the GEO satellite constellation, initially for maritime use, and then for land, aeronautical and personal communication and tracking, at 1.6/1.5GHz of L-band (Service Link) and at 6.4/3.6GHz of C-band (Feeder Link).

The Inmarsat D+ tracking terminal is based on the Inmarsat-C standard as the best solution for SAT via satellites including GMT. It is able to transmit and receive data anywhere via the Inmarsat network and is ideal for asset tracking, fleet management and SCADA applications. Since its terminals are low power, they can be used with onboard power supplies or batteries, and when combined with sensors they can display parameters of their environment, such as mileage, fuel consumption, temperature and so on.

SkyWave manufactures reliable civilian and military GMT terminals for Inmarsat satellite tracking and detection. These small terminals offer reliable communications for defense organizations, which operate in some of the world's harshest and most remote environments, out of reach of most communications systems.

The SkyWave terminals are fully programmable and low power, optimized to work over satellite and even terrestrial networks. They provide PVT data communications for effective and efficient tracking, monitoring, control and management of personnel, equipment and mobile devices, regardless of location.

There are five reasons to choose this type equipment and service:

1. **Personnel Safety:** to co-ordinate the location of friendly units for full situational awareness, and text messaging field personnel in dangerous or remote regions.
2. **Defense Asset Tracking:** to track the location of military vehicles, trailers and containers.
3. **Cargo Security:** to monitor container doors to detect cargo theft and ensure security.
4. **Increase Efficiency:** to transmit electronic documents such as order instructions, for example.
5. **Access Control and Logistics:** to transmit identification of personnel on transport buses.

Figure 4a shows the first generation of SkyWave Inmarsat D+, whereas Figure 4b (top) shows the third generation of SkyWave Inmarsat IsatData IDP 600 series SAT for maritime applications. Figure 4b (bottom) shows the same terminal for land (vehicle) applications. These terminals can even be used for aircraft tracking if the integrated GPS Rx is adapted to work under high-speed conditions.

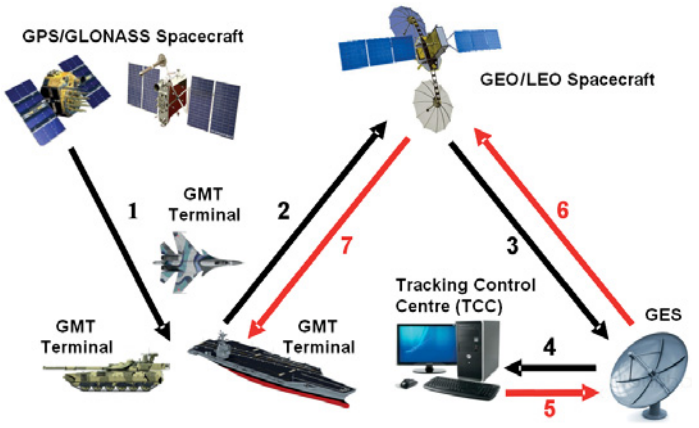

Figure 2: Configuration of GMT via GNSS and GEO/non-GEO satellites

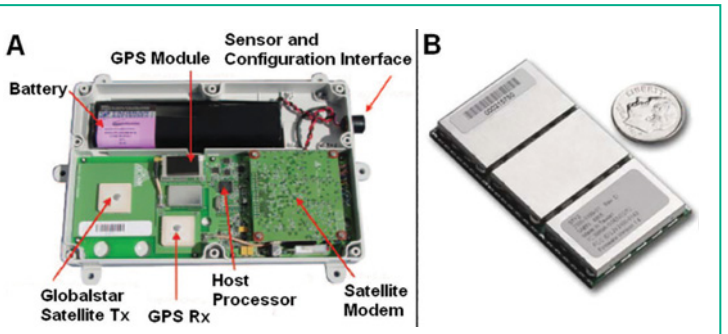

Figure 3: Configuration of the SAT equipment

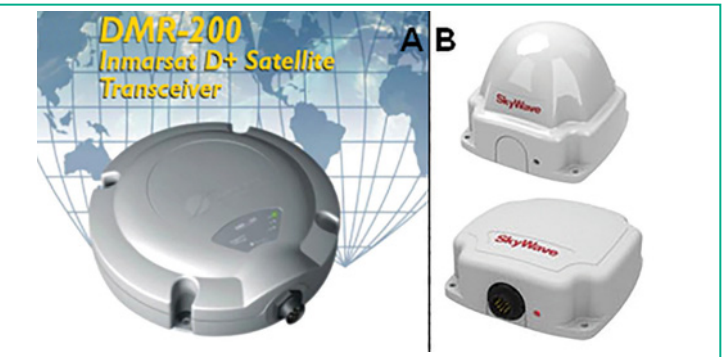

Figure 4: First and second generation Inmarsat SkyWave SAT terminals

Tracking And Detecting Via Iridium

The Iridium satellites are situated in near-polar orbit, at an altitude of 780km. They circle the Earth once every 100 minutes at a rate of about 26,856km/h.

Each satellite is cross-linked to four other satellites with two

Figure 5: Iridium miniature satellite trackers

satellites in the same orbital plane and two in an adjacent plane. The Iridium constellation consists in 66 operational satellites and 14 spares orbiting in six polar planes.

The Iridium system provides a real global coverage and roaming via 48 spot overlapping-beams, with the diameter of each spot being about 600km. Iridium as a truly global operator, providing voice and data services including SAT for all mobile applications via an uplink/downlink at 1621.35-1626.5MHz, feeder links at 29.129.3GHz of Ka-band (uplink) and 19.4-19.6GHz of K-band (downlink). It offers many types of SAT transponders for all mobile and personnel applications:

1. **Quake 9602 Mini Tracker** – The 9602 is a Short Burst Data (SBD) transceiver designed for use as a basic unit for many trackers using the Iridium network (see Figure 5a). This very tiny (41 x 45 x 13mm) unit, weighing just 27.22 grams, is a two-way transceiver, perfect for use for all mobiles and aircraft, and for fixed remote asset tracking and M2M monitoring solutions.

   This Iridium unit can be connected to onboard GPS via built-in GPS input/output ports. However, other similar units have integrated GPS receiver and they are able to work independently of the onboard mobile GPS Rx.
2. **Quake Q-Pro Multipurpose Tracker** – This unit is 119.2 x 119.4 x 57.6mm large and weighing 390.6 grams. It is a rugged multi-satellite GPS/Iridium, Globalstar, Orbcomm and GSM modem, see Figure 5b.
3. **E-Track Alpha Tracker** – This unit is an autonomous, real-time satellite-tracking device, which provides global coverage via the Iridium network, see Figure 5c. Features of this 116 x 64 x 46mm and 239gr-weighing unit include automatic transmission of PVT and other data.

Figure 6: Iridium personal satellite trackers

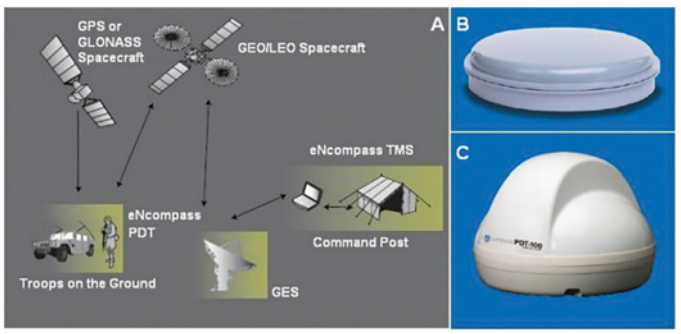

Figure 7: Honeywell GPS/GLONASS GEO/LEO military satellite tracking network and GMT terminals

Personal Tracking And Detection Via Iridium

The following Iridium personal satellite trackers are ideal units for tracking of mobile crew and personnel:

1. **E-Track Epsilon Personal Tracker** – This tracker is a waterproof satellite messaging and personal tracking device, providing autonomous real-time and global coverage (see Figure 6a). Developed around the 9602 Iridium modem, it benefits from the latest developments in satellite technology of GPS and is IP67 rated. The unit provides two-way text messaging, with a predefined and free-text "HELP" key to send a distress message with an accurate GPS position of the incident.
2. **GeoPro Personal Messenger** – This personal terminal is a remote-workforce safety and location awareness and a two-way personal messaging solution (see Figure 6b). When work takes staff in the field, they often have no reliable means of maintaining communication. This affordable and rugged device supports global two-way text messaging and can be used in one hand, allowing joystick navigation of on-display menus and keyboard.
3. **NANO Personal Tracker** – This pocket-sized unit shown in Figure 6c has ultra-low power consumption (less than 35µA during sleep). This self-contained personal satellite tracker provides 256-bit transmit and receive encryption, precise GPS positioning, real-time reporting and a truly global coverage.

Military Transportation Management System

The military Transportation Management System (TMS) is a logistics communications platform, designed for commanders to track mobile assets and personnel on the battlefield with encrypted text messaging of PVT data via GMT terminals. The PVT data can also contain heading, altitude (for aircraft) and ID of the mobile device or soldier.

This is a satellite tracking, detecting and communicating system, dedicated to providing command and control over distributed assets supporting and conducting theater operations. The system provides units with digital Geographic Information System (GIS) maps, GPS or GLONASS GNSS location data, and a L-band GEO/LEI satellite two-way text messaging system, the network of which is shown in Figure 7a. Troops on the ground are typically equipped with Honeywell (ex-EMS Satcom) GMT terminals, such as the eNcompass PDT-300i, shown in Figure 7b (top) or eNcompass PDT-100, shown in Figure 7b (bottom).

The eNcompass terminals have integrated GNSS and satellite transceivers with both antennas, which have to be well protected by plastic radome and properly mounted atop road vehicles. The requirements are the same for military ships and aircraft installations. However, soldiers on the field or in mobile units can use personal tracking and detection terminals, shown in Figure 6.

The TMS network can operate anywhere in the world giving over-the-horizon communications to ships, vehicles, aircraft and personnel on the move. Messages are transmitted via already discussed commercial satellites in near real-time and vehicle locations are displayed on computers with GIS maps. Thus, the GMT transponders of TMS networks operate over a variety of existing GEO satellite constellations and are designed to transition automatically from one satellite system to another, as required by the situation on the ground. Some GMT terminals are even designed to work via three satellite operators, such as Inmarsat, Iridium, Globalstar and Orbcomm. Otherwise, all messages are encrypted end-to-end, including sender and recipient addresses for information security purposes.

The TMS computer systems come in two configurations: a mobile system that mounts on tactical vehicles and a laptop control station for use at a command post or higher headquarters. With such a system implemented, soldiers can communicate with other TMS-enabled vehicles and control stations, as well as assess their own position. It is ideal for accurately identifying current vehicle locations and sending messages to and from the unit. With these two systems, the commander has accountability of the missions and directed orders, and the subordinate units have a higher level of protection due to the ability of the system. Leaders can easily and securely pass critical information – such as mission changes, alternate routes and other information essential to the mission – to subordinate units in the field. ●

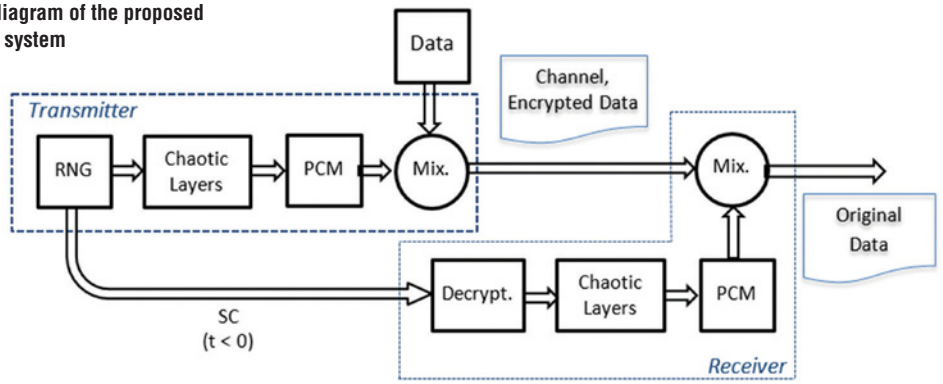

Figure 1: Block diagram of the proposed communications system

A NEW SECURE COMMUNICATIONS METHOD USING CASCADE CHAOTIC COMPUTING SYSTEMS

AHMET SERTOL KOKSAL AND **H. EVIRGEN** FROM THE SAKARYA UNIVERSITY IN TURKEY PRESENT A NEW SECURE COMMUNICATIONS APPROACH BASED ON DISCRETE-TIME CHAOTIC SYSTEMS

Ensuring data secrecy in communication networks is vital for a secure communication system. Encryption with a public or private key to ensure secrecy is the most familiar method. The chaos theory began to be used in communication systems as a result of studies conducted by Pecora and Carroll in 1990 and new methods were included in the encryption category.

Chaotic signal characteristics allow powerful encryption methods and development of more secure communication systems. In studies conducted in recent years, chaotic masking, chaotic modulation, parametric modulation, inclusion, chaotic shift keying and similar methods [1-6] have been used. Most of these studies are based on synchronization of chaotic systems present in the receiver and transmitter. Different techniques were used to ensure synchronization, and observer-based control systems were incorporated in most applications [7-12]. In some of these studies, however, there were systems designed without synchronization [13].

Our study is based on the principle of sending encrypted scalar data before the start of communication, for the synchronization of receiver and transmitter. Encryption is achieved with the RSA algorithm by using public or private key. This encrypted data provides operation of chaotic layers in the receiver and transmitter under the same initial conditions, so a separate control system is not needed for synchronization.

System Description

The block diagram of our communication system is shown in Figure 1. The system consists of four main parts: Random Number Generator (RNG), Chaotic Calculation Layer (CCL), Pulse Code Modulation (PCM) and a Mixer layer.

The main duty of the RNG is to determine the initial conditions of a chaotic system. For this purpose, before starting data transmission, random numbers are generated in this section and encrypted with the RSA algorithm. We call this encrypted scalar data Synchronization

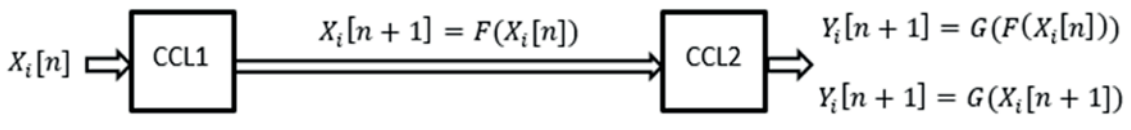

Figure 2: Block diagram of chaotic calculation layers and their mathematical expressions

Code (SC). Just before beginning data transmission, the SC is sent to the receiver, which decrypts it and stores it in cache memory.

The second part is the CCL, where two discrete time chaotic systems are connected. The first system (CCL1) uses random numbers produced by the RNG as an initial condition and prepares an F function value which determines the initial condition for CCL2. Then, CCL2 calculates the next value with a G function, thus the initial conditions are constantly changed, depending on the F function. The block diagrams of CC1 and CCL2 and their mathematical expressions are shown in Figure 2.

The third part is PCM. Values calculated in the CCL2 exit are converted into binary numbers in the PCM layer. This number consists of N bits and we call it the 'codeword'.

In the Mixer layer, the N bits of data sent with the codeword are mixed according to a specific logic function, and then encrypted and sent to the communication channel. So, after the receiver receives the SC information, it decrypts it and triggers the CCL, which is configured in the same way, making the receiver and transmitter operate with the same initial conditions and in sync. Codewords are generated in the receiver as well as the transmitter. These codewords, which are generated throughout the communication, as well as the encrypted data, are re-mixed and decrypted in the last layer, so the original data is obtained.

Image Encryption Application

In this part, numerical analysis was conducted with the communication system we designed for digital image encryption. The first of the CCLs is the discrete-time Rössler system [14]. Its description correlation is:

$$X_1[n+1] = 3.8X_1[n](1 - X_1[n]) - 0.05(X_3[n] + 0.35)(1-2X_2[n]) \quad (1)$$
$$X_2[n+1] = 3.78X_2[n](1 - X_2[n]) + 0.2X_3[n] \quad (2)$$
$$X_3[n+1] = 0.1(1 - 1.9X_1[n])((X_3[n] + 0.35)(1 - 2X_2[n]) - 1] \quad (3)$$

The second system is the discrete-time Henon system [8]:

$$Y_1[n+1] = 1.76 - Y_2^2[n] - 0.1Y_3[n] \quad (4)$$
$$Y_2[n+1] = Y_1[n] \quad (5)$$
$$Y_3[n+1] = Y_2[n] \quad (6)$$

In this application, the RNG numbers are in the interval (-1, 1). The Y_3 value, which was calculated according to the established initial conditions, was used in the PCM layer. The obtained value was then separately coded as 3-bit and 8-bit; the XOR function was used as a mixer.

The AES algorithm was used to encrypt the SC, and a binary conversion performed with medium-height linear quantizer in the PCM layer. Graphs that belong to the original, encrypted and decrypted images obtained for the 1658 x 1642-pixel coloured photograph are

Figure 3a: Original image

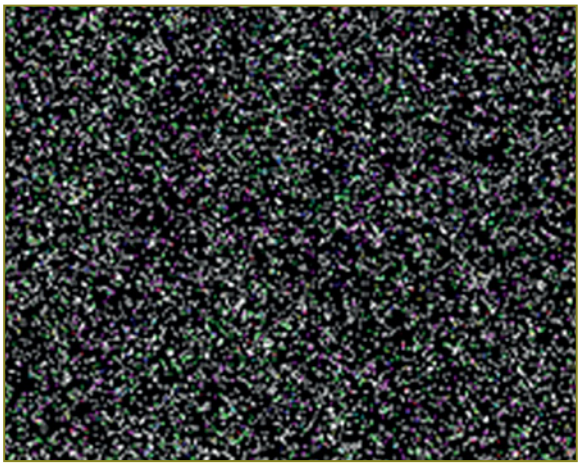

Figure 3b: Encrypted image

Figure 3c: Decrypted image

shown in Figure 3. All calculations were performed in MATLAB.

It was observed that data obtained as a result of experimental studies conducted in a simulation environment can be used for image encryption in the area of secure communication.

Difficult To Hack

Secure data, generated by our system before data transmission, is sent to a receiver encrypted with a 128-bit AES block cipher. This code ensures the synchronization of receiver and transmitter and fulfills the authentication function.

Unlike the current chaotic encryption methods, a layered chaotic structure was designed in which the initial conditions of the second layer are constantly re-generated by the first layer. Constantly and dynamically changing initial conditions make it difficult for ciphers to be seized by a hacker; as long as a hacker does not know how many bits of coding are performed in the PCM layer and which logic algorithm is used in the mixer, the system is secure.

In summary, each section of this four-part system provides a distinct security, making the solution novel. Its applicability was tried and successfully tested with an image encryption application in a simulation environment.

Since this system does not require intense mathematical operations, it can be adapted to fast communication systems. It will also pave the way for future studies, potentially adapted for use on Gbit Ethernet, ATM and FrameRelay networks in particular. ●

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NETWORK INTRUSION DETECTION: A USABILITY COMPARISON STUDY ON NEURAL NETWORKS

ORHAN ER FROM BOZOK UNIVERSITY IN TURKEY PROPOSES A METHODOLOGY FOR EVALUATING CURRENT INTRUSION-DETECTION SYSTEMS' CAPABILITIES OF DETECTING ATTACKS TARGETING NETWORKS AND THEIR SERVICES

The Internet is becoming a universal communications network, conveying different types of information: from a simple transfer of binary computer data to the real-time transmission of voice, video and interactive information. And as it evolves from a single best-effort service to a multiservice network, it becomes highly exposed to attacks; a tiny amount of attacking traffic can easily be hidden in a large amount of cross-Internet traffic.

Security

The security of network systems is becoming increasingly important as more and more sensitive information is stored and processed online. Intrusion Detection Systems (IDSs) have thus become a critical technology to help protect these systems.

Intrusion detection is the process of monitoring and analyzing events that occur in a computer or networked systems. IDS employs techniques for modelling and recognizing a variety of intrusive system behaviours. It dynamically monitors the events taking place in a system and decides if these events are symptomatic of an attack or constitute a legitimate use of the system.

Traditional intrusion prevention techniques, such as firewalls, access control or encryption, have failed to fully protect networks and systems from increasingly sophisticated attacks and malware. As a result, IDS has become an indispensable component of security infrastructure, detecting threats before they inflict widespread damage. It monitors networked devices and looks for anomalous or malicious behaviour in the patterns of activity in the audit stream.

A comprehensive IDS requires a significant amount of human expertise and time for development, but it has become an integral part of any well-configured and well-managed computer system or network.

Complex Structures

It is clear that firewalls are not enough to secure a network completely, because attacks committed from outside of the network are stopped, whereas inside attacks are not. This is where IDSs take charge. They stop attacks, recover from them with minimum loss and analyze the security problems so they are not repeated.

We are also increasingly seeing Artificial Neural Network (ANN) structures for classification systems in computer security, applied in a variety of intrusion detection contexts, where they perform pre-processing of input data.

Multi-Layer Neural Networks (MLNNs), Probabilistic Neural Networks (PNNs) and Learning Vector Quantization (LVQ) neural networks have been successfully used to replace conventional pattern-recognition methods. Of these, the MLNN structure is most commonly and successfully used for classification problems. The Back-Propagation (BP) algorithm is widely recognized as a powerful tool for training MLNN structures. However, this algorithm suffers from a slow convergence rate and often yields suboptimal solutions. The Levenberg-Marquardt (LM) algorithm used in this study provides generally faster convergence and better estimation results than other training algorithms.

Dataset	(0) Normal	(1) Probe	(2) DoS	(3) U2r	(4) R2l
Total Dataset	9,906 (33.02%)	4,107 (13.69%)	14,809 (49.36%)	52 (0.17%)	1,126 (3.76%)
Training Dataset	6,604 (22.01%)	2,738 (09.13%)	9,873 (32.91%)	35 (00.12%)	751 (02.50%)
Testing Dataset	3,302 (11.01%)	1,369 (04.56%)	4,936 (16.45%)	17 (00.05%)	375 (01.25%)

Table 1: Training and testing dataset by KDD99

> The probabilistic neural network structures provide a general solution to pattern classification problems by following an approach developed in statistics, called Bayesian classifiers

The probabilistic neural network structures provide a general solution to pattern classification problems by following an approach developed in statistics, called Bayesian classifiers. The PNN uses a supervised training set to develop distribution functions within a pattern layer. Training PNNs is much simpler than that of the MLNNs. However, the pattern layer can be quite huge if the distinction between categories is varied and at the same time quite similar in special areas (Specht, 1990). Because the PNN provides a general solution to pattern classification problems, it is suitable for the IDS problems.

Classification of the learning vector quantization neural network structure is based on the similarity of the unknown data and these prototypes. An LVQ neural network has a competitive layer and a linear output layer. The competitive layer learns to classify input vectors, while the linear output layer transforms the competitive layer's classes into target classifications defined by the user. The classes learned by the competitive layer can be referred to as subclasses, while the classes of the linear output layer are called target classes.

For this article, a comparative study on IDS was conducted using artificial neural networks. The IDS datasets were prepared by the KDD99 database and the results compared with those of previous studies.

Method

The KDD99 dataset was derived in 1999 from the DARPA98 network traffic dataset by assembling individual TCP packets into TCP connections. It was the benchmark dataset used in the International Knowledge Discovery and Data Mining Tools Competition and, also, the most popular dataset that has ever been used in the intrusion detection field. Each TCP connection has 41 features, with a label that specifies its status as either normal or a specific attack type. There are 38 numeric features and three symbolic features, falling into the following four categories:

- **Basic features:** Nine basic features describe each individual TCP connection (Probe).
- **Content features:** Thirteen domain-knowledge-related features indicate suspicious behaviour with no sequential patterns in the network traffic.
- **Time-based traffic features:** Nine features summarize the connections in the past 2s with the same destination host or the same service as the current connection.
- **Host-based traffic features:** Ten features use a window of 100 connections to the same host instead of a time window, because slow-scan attacks may last longer than 2s.

The KDD99 intrusion detection benchmark consists of training and testing dataset (see Table 1). Since this training set is prohibitively large, another training set was used, which randomly sampled normal records from the KDD dataset. The test dataset contains 30,000 connections and the task is to predict the value of each connection (normal or belonging to a specific attack category).

The test data includes some specific attack types not present in the training data. The datasets contain a total of 24 training attack types, with an additional 14 types in the test data only. The remaining attacks are present in the test dataset with different rates consistent with their corresponding categories.

The described experiments were implemented using the MATLAB 2009b environment, on an Intel Core Duo 2 2.0GHz CPU with 3GB memory.

Intrusion Detection Using A Multi-Layer Neural Network

In the first stage of the study, the multilayer neural network structure with one and two hidden layers was used for intrusion detection. This multilayer neural network structure (with one input layer, two hidden layers and one output layer) is shown in Figure 1.

The hidden-layer neurons (85 neurons for each layer) and the output-layer neurons use nonlinear sigmoid activation functions. In this system, four inputs are features and five outputs are index of five classes (normal, Probe, DoS, U2R and R2L). The equations used in the multilayer neural network structure with two hidden layers are shown in Equations 1-3.

Outputs of the first hidden layer neurons are as follows:

$$\vec{X}^{ih1}(n) = 1 \Big/ \left(1 + \exp\left(W^{ih1}(n) * \vec{f}(n) + \vec{b}^{ih1}(n)\right)\right) \quad (1)$$

Outputs of the second hidden layer neurons are:

$$\vec{X}^{ih2}(n) = 1 \Big/ \left(1 + \exp\left(W^{ih2}(n) * \vec{X}^{ih1}(n) + \vec{b}^{ih2}(n)\right)\right) \quad (2)$$

Outputs of the network are:

$$\vec{Y}(n) = 1 \Big/ \left(1 + \exp\left(W^{ho}(n) * \vec{X}^{ih2}(n) + \vec{b}^{ho}(n)\right)\right) \quad (3)$$

where $W^{ih1}(n)$ are the weights from the input to the first hidden layer;
$\vec{b}^{ih1}(n)$ are the biases of the first hidden layer;
$W^{ih2}(n)$ are the weights from the first hidden layer to the second hidden layer;
$\vec{b}^{ih2}(n)$ are the biases of the second hidden layer;
$W^{ho}(n)$ are the weights from the second hidden layer to the output layer;
$\vec{b}^{ho}(n)$ are the biases of the output layer;
$\vec{f}(n)$ values are the features;
$\vec{Y}(n)$ values are the outputs for the class index;
and n is the training pattern index.

The back-propagation (BP) algorithm is widely recognized as

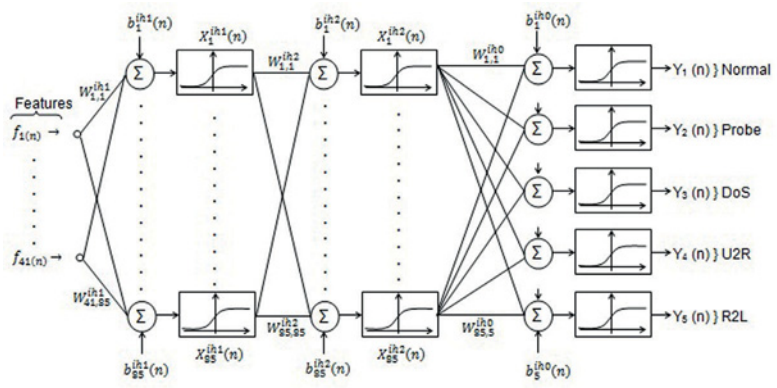

Figure 1: Implementation of a multilayer neural network for an intrusion detection system

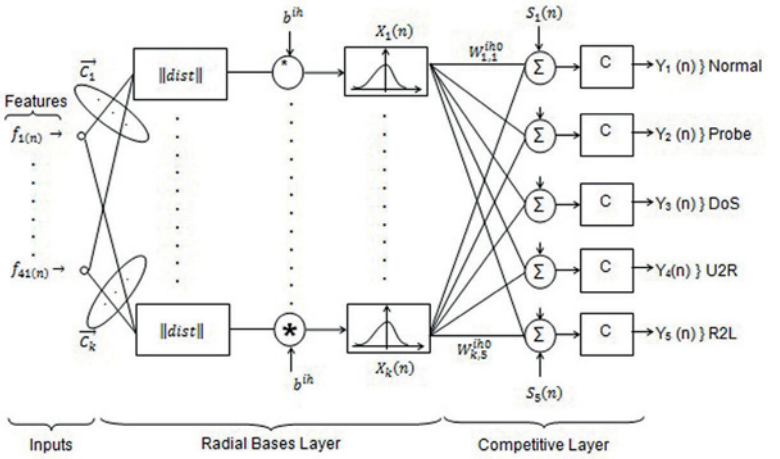

Figure 2: Implementation of a probabilistic neural network for intrusion detection

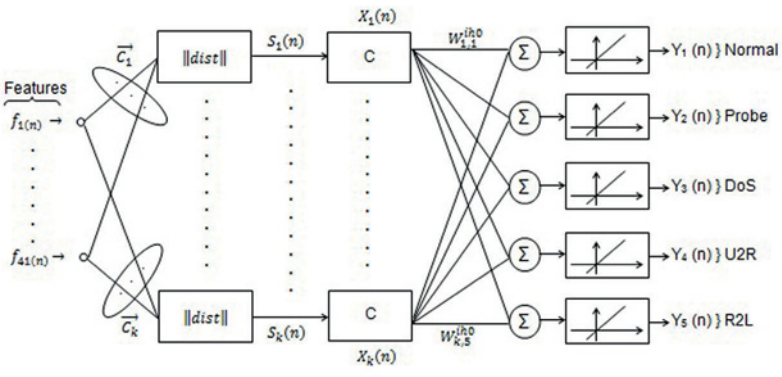

Figure 3: Implementation of learning vector quantization neural network for an intrusion detection system

a powerful tool for training MLNNs, but since it applies the steepest descent method to update the weights, it suffers from a slow convergence rate and often yields suboptimal solutions.

A variety of related algorithms has been introduced to address this problem. A number of researchers have carried out comparative studies of MLNN training algorithms, including the Levenberg-Marquardt (LM) algorithm (also used in this study), which is one of the fastest.

Intrusion Detection Using A Probabilistic Neural Network

In the second stage of this study, a probabilistic neural network was used for intrusion detection; its structure is shown in Figure 2.

It can be seen that this is a multilayer structure, consisting of an input layer, a single hidden (radial basis) layer and an output (competitive) layer. In this system, the real valued input vector is feature's vector, and five outputs are index of five classes (normal, Probe, DoS, U2R and R2L). All hidden units simultaneously receive the 41-dimensional real valued input vector (see Equations 4-8).

$$X_j = \phi\left(\left\|\vec{f} - \vec{c_j}\right\| * b^{ih}\right) \tag{4}$$

$$\phi(x) = \exp\left(-x^2\right) \tag{5}$$

$$b^{ih} = 0.833/s \tag{6}$$

$$S_i = \sum_{j=1}^{h} W_{ji}^{ho} * X_j \tag{7}$$

$$Y_i = \begin{cases} 1, & if\ S_i\ is\ \max\ of\ \{S_1, S_2, S_3\} \\ 0, & else \end{cases} \tag{8}$$

where $i = 1,2,...,5$; $j = 1,2,...,h$;
Y_i is the i^{th} output (classification index);
$\vec{f}$ is the 41-dimensional real valued input vector;
W_{ji}^{ho} is the weight between the j^{th} hidden node and the i^{th} output node;
$\vec{c_j}$ is the centre vector of the j^{th} hidden node;
s is the real constant known as spread factor;
b^{ih} is the biasing term of radial basis layer;
and $\phi(.)$ is the nonlinear radial basis function (Gaussian).

The PNN structures employed in the study used the newpnn function implemented in MATLAB.

Intrusion Detection Using A Learning Vector Quantization Neural Network

In the third stage of this study, a learning vector quantization neural network was used for the IDS; its structure is shown in Figure 3.

As can be seen, the LVQ structure used in this study is also a multilayer one, consisting of a single hidden (competitive) layer

and an output (linear) layer of five units. In this system, real valued input vector is feature's vector, and six outputs are index of five classes (normal, Probe, DoS, U2R and R2L). The hidden layer consists of a set of competition functions. Equations 9-11 were used in the neural network model.

$$S_j = \left\| \vec{f} - \vec{c}_j \right\| \tag{9}$$

$$X_j = \begin{cases} 1, & if\ S_j\ is\ \max\ of\ \{S_1,\ldots,S_h\} \\ 0, & else \end{cases} \tag{10}$$

$$Y_i = \sum_{j=1}^{h} W_{ji}^{ho} * X_j \tag{11}$$

where $i = 1,2,\ldots,5;\ j = 1,2,\ldots,h;$
Y_i is the i^{th} output (classification index);
$\vec{f}$ is the 41-dimensional real valued input vector;
W_{ji}^{ho} is the weight between the j^{th} hidden node and the i^{th} output node;
and $\vec{c}_j$ is the centre vector of the j^{th} hidden node.

The LVQ structures employed in the study used the newlvq function implemented in MATLAB.

Neural Network Performance Evaluation

The performance of ANN was evaluated by classification accuracy and k-fold cross-validation.

Classification accuracy

We've used classification accuracies as performance measures:

$$classification\ accuracy(N) = \frac{\sum_{i=1}^{|N|} assess(n_i)}{|N|}, \quad n_i \in N \tag{12}$$

$$assess(n) = \begin{cases} 1 & if\ classify(n) = nc \\ 0 & otherwise \end{cases} \tag{13}$$

where N is the set of data items to be classified (the test set); $n \in N$, nc is the class of the item n, and $classify\ (n)$returns the classification of n by neural networks.

The performances of each method are measured according to the detection rate and false positive rate calculated using the following expressions:

$$Detection\ Rate = 1 - \frac{False\ negatives\ number}{Total\ number\ of\ attacks} \tag{14}$$

$$False\ Positive\ Rate = \frac{False\ Positives}{Total\ number\ of\ normal\ connection} \tag{15}$$

References	Dataset	Method	NORMAL (%)	PROBE (%)	DoS (%)	U2R (%)	R2L (%)
Ref [2]	10% of the KDD training data randomly sampled	Optimal decision trees	-	84.50	97.50	11.80	7.32
Ref [25]	KDD dataset which contained new R2L attacks	PNrule	-	73.20	96.90	6.60	10.70
Ref [26]	KDD records, the data set size reduced to 45,000 records.	K-means algorithm	-	91.88	97.85	5.60	77.04
		SNN technique	-	73.43	77.76	37.82	68.15
Ref [27]	30,000 randomly sampled normal records from the KDD data set	Parzen-window estimators with Gaussian kernels	-	99.17	96.71	93.57	31.17
Ref [28]	KDD -10% version of the full dataset	Hybrid AIS and Kohonen Self Organizing Map (SOM)	99.40	64.70	96.80	34.60	5.20
Ref [29]	KDD -10% version of the full dataset	Hierarchy of Kohonen Self Organizing Map (three layers)	95.40	64.30	95.10	10.00	9.90
Ref [30]	KDD -10% version of the full dataset	Cost-sensitive bagged boosting of decision trees	99.50	83.30	97.10	13.20	8.40
This Study	30,000 randomly sampled normal records from the KDD data set	MLNN with LM (two hidden layers)	99.17	90.18	97.33	39.84	73,33
		PNN	**99.73**	**99.17**	**98.24**	**41.21**	**80.84**
		LVQ	99.57	91.22	97.32	39.67	77.08

Table 2: Performance comparisons (correct detection rate)

KDD Winner [39]			This Study [3-fold validation]		
	training	test		training	test
0:	19.69 %	19.48 %	0:	22.01 %	11.01 %
1:	00.83 %	01.34 %	1:	09.13 %	04.56 %
2:	79.24 %	73.90 %	2:	32.91 %	16.45 %
3:	00.01 %	00.07 %	3:	00.12 %	00.05 %
4:	00.23 %	05.20 %	4:	02.50 %	01.25 %

Table 3: Actual distributions of attack types in the training and test 10% datasets

References	Dataset
Detection rate	95.94%
False alarm rate	3.02%
Execution run time	48 hour 21 minute
Classification rate	93.80%

Table 4: Performance results for the study

k-Fold cross-validation

In order to minimize the bias associated with random sampling of the training and holdout data samples in comparing the predictive accuracy of two or more methods, researchers tend to use k-fold cross-validation. In k-fold cross-validation, whole data are randomly divided into k mutually exclusive and approximately equal size subsets.

The classification algorithm was trained and tested k times. In each case, one of the folds is taken as test data and the remaining folds are added to form training data. Thus k different test results exist for each training-test configuration. The average of these results gives the test accuracy of the algorithm. If a neural network learns the training set of a problem, it makes generalizations to that problem. So, this type of trained neural network also gives similar result for untrained test sets. But, if a neural network starts to memorize the training set, its generalization begins to decrease and its performance may not improve for the untrained test sets.

The k-fold cross-validation method shows how good generalization can be made using neural network structures. In this study, 3-fold cross-validation approaches were used to estimate the performance of the subject neural networks.

Results

The correct detection rate for each class and average values obtained by neural networks structures for IDS are shown in Table 2, which also shows the correct detection rates for each class and average values obtained by the related work using KDD99 dataset.

Results confirm that our study produced very good, correct, detection rates of 99.73%, 99.17%, 98.24%, 41.21% and 80.84% on the Normal, Probe, DoS, U2R and R2L attack classes, respectively by MLNN, PNN and LVQ structures. These are very good results compared to the best-in-class Parzen-window estimators with Gaussian kernels (99.17%, 93.57%). Although they are especially good performances, the results for the R2L class are not satisfactory. So, our study is second-best after the Parzen-window estimators with Gaussian kernels.

Knowledge about network intrusions suggests that the U2R and R2L categories are intrinsically rare. Actual distributions of attack types in the training and test 10% datasets are shown in Table 3.

Most studies have low detection and classification rates for U2R and R2L attacks, suggesting that such attacks are indeed problematic for IDSs. If classification of these two attack types is considered a trade-off, as previously discussed, then the results from our system are favourable.

Our study will hopefully contribute to improving information and computer security in the near future and bring more awareness of the security issues we face. ●

RELATED WORK

Here are some ways of designing IDSs using a KDD dataset only.

Using the Kernel Miner tool [2], Levin created a set of locally optimal decision trees (called the "decision forest") from which an optimal subset of trees (called the "sub-forest") was selected for predicting new cases. Levin used only 10% of the KDD training data randomly sampled from the entire training dataset. Multi-class detection approach was used to detect different attack categories in the KDD dataset. The authors reported 84.5% detection for probing attacks, 97.5% detection for DoS attacks, 11.8% detection for U2R attacks and only 7.32% detection for R2L attacks.

Agarwal and Joshi [25] proposed a two-stage, general-to-specific framework for teaching a rule-based model (PNrule) to learn classifier models on a dataset that has widely different class distributions in the training data. The PNrule technique was evaluated on the KDD testing dataset, which contained many new R2L attacks not present in the training dataset. The authors reported 73.2% detection for probing attacks, 96.9% detection for DoS attacks, 6.6% detection for U2R attacks, and 10.7% detection for R2L attacks.

Ertöz et al [26] used shared nearest neighbour (SNN) technique, which is particularly suited for finding clusters in data of different sizes, density and shapes, mainly when the data contains large amount of noise and outliers. All attack records were selected from the KDD training and testing datasets. This set was then used to train two clustering algorithms: K-means and the proposed SNN technique, which were compared in terms of detection rates achieved. The authors reported 91.88% detection for probing attacks, 97.85% detection for DoS attacks, 5.6% detection for U2R attacks and 77.04% detection for R2L attacks using the K-means algorithm. They reported 73.43% detection for probing attacks, 77.76% detection for DoS attacks, 37.82% detection for U2R attacks, and 68.15% detection for R2L attacks using SNN technique.

Yeung and Chow [27] proposed a novel detection approach, using non-parametric density estimation based on Parzen-window estimators with Gaussian kernels to build an IDS with normal data only. The authors reported 99.17% detection for probing attacks, 96.71% detection for DoS attacks, 93.57% detection for U2R attacks and 31.17% detection for R2L attacks. It is important to note that this model detects whether a record is intrusive or not without identifying which specific category it may belong to, which is a significant limitation.

Powers & He [28] used a hybrid artificial immune system and Self Organising Map (SOM) for attack detection and classification on the same 10% of KDD dataset. The first system was chosen because it also uses a SOM, whilst the second was chosen as a standard benchmark reference result. The authors reported 99.40% detection for normal attacks, 64.70% detection for probing attacks, 96.80% detection for DoS attacks, 34.60% detection for U2R attacks and 5.20% detection for R2L attacks.

Kayacik et al [29] based their method purely on a hierarchy of Self-organizing Feature Maps for both attack detection and classification. They used only 10% of the KDD training data randomly sampled from the entire training dataset. The authors reported 99.40% detection for normal attacks, 64.70% detection for probing attacks, 96.80% detection for DoS attacks, 34.60% detection for U2R attacks and 5.20% detection for R2L attacks.

Pfahringer [30] used based cost-sensitive bagged boosting of decision trees for both attack detection and classification, and reported 99.50% detection for normal attacks, 83.30% detection for probing attacks, 97.10% detection for DoS attacks, 13.20% detection for U2R attacks and 8.40% detection for R2L.

For all practical purposes, most researchers applied a single algorithm to address all four major attack categories including DoS, Probing, R2L and U2R, and have applied distinctly unique execution dynamics and signatures [31].

RELATED WORK

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SIMULTANEOUS AUTHENTICATION AND AUTHORIZATION MECHANISMS FOR A MASSIVELY LARGE MULTIMEDIA BROADCASTING SERVICE

DENG ZHONGLIANG, LIN WENLIANG, LI NING, HAN KE, HOU YUNLONG AND **ZHANG LIN** FROM BEIJING UNIVERSITY OF POST AND TELECOMMUNICATIONS PROPOSE AN EFFICIENT AUTHENTICATION AND AUTHORIZATION METHOD FOR SIMULTANEOUSLY BROADCASTING MASSIVELY LARGE MULTIMEDIA INFORMATION

With the support of the high-power S-band satellite and additional ground antenna systems, the China Mobile Multimedia Broadcasting (CMMB) combines a uni-directional broadcasting service and a bi-directional mobile multimedia communications system. As such, CMMB is capable of handling very large amounts of data, supported by bi-directional authorization between user and service. However, with the heavy increase in its users, the authentication and authorization processes can experience challenges.

The traditional CMMB conditional access system (CAS) uses a bi-directional channel to transmit the EMM (Entitlement Management Message), typically generated by the broadcasting operator's user key. The mobile operator's user key then encrypts this EMM information, which is transmitted to the user terminal. However, since the user identity has to match the user key and EMM, this bi-directional transmission method takes a lot of bandwidth, which in turn leads to network congestion. So, researchers worldwide are working on developing an efficient and simple yet fast authentication and authorization solution.

Our system resolves issues generated by broadcasting massive simultaneous multimedia data to a large group of users with a single type of service authentication. We've designed a single key to authenticate multiple services, which effectively manages system capacity, allowing businesses to improve their bandwidth utilization.

CMMB Conditional Access Mechanism

The authentication process of our conditional access mechanism completes the certification between user and service, permitting only legitimate users (i.e. their terminals/receivers or secure SD cards with onboard MCUs) access to the mobile multimedia broadcast services to go through the process.

In our system, there are several modules: for authentication, authorization, encryption and scrambling. We propose a scheme that sets the end user's SD card as the main authentication element, without having to identify the user's terminal or mobile phone number. This also permits users to enjoy paid CMMB services from any terminal or phone number, by using their SD card only. Because this brings some authentication issues, the authentication process between SD card, terminal and phone number is of critical importance.

When the SD card is inserted into a terminal, it automatically instigates the authentication process, which verifies the links between the associated terminal and SD card, terminal and phone number, and terminal and network.

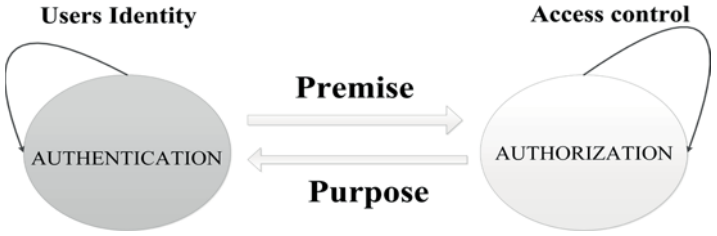

Figure 1: The relationship between authentication and authorization

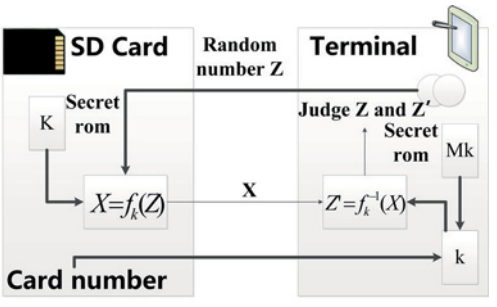

Figure 2: The mechanism linking the SD card and terminal based on the symmetric key authentication

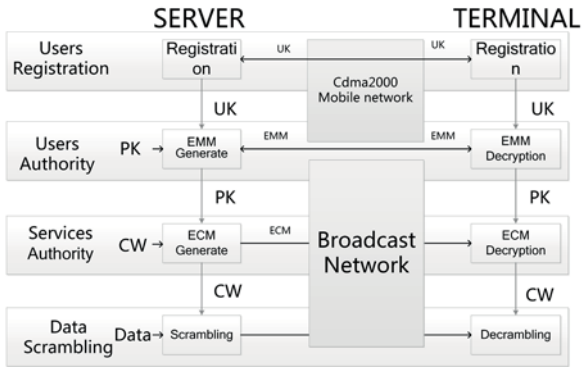

Figure 3: Massive services authorization based on four layers

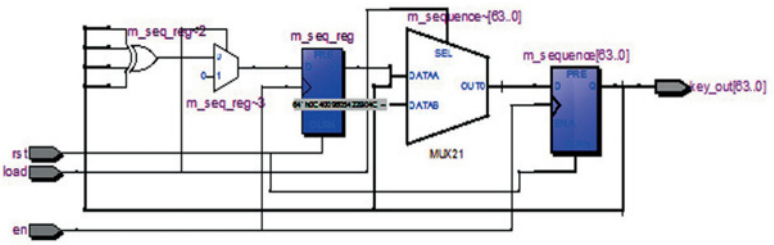

Figure 4: The circuit's RTL diagram

Symmetric Key Based Mechanism

The encryption algorithm based on symmetric key checks the key that encrypts the information generated by the request-response between SD card and terminal. These keys, called "k" and "Mk", are symmetric, which means they are produced by the same key-generating machine at the same time as the control key.

The algorithm then undertakes the following steps:

a) Keys "k" and "Mk" are separated and stored in a protected ROM of the SD card and terminal.

b) When the association process starts, the terminal generates a random number called "Z", and sends it to the SD card via the encrypted channel. After the SD card receives this number "Z", the SD card's MCU calculates a secret response number "X" according to the formula $X = f_k(Z)$. X is then sent to the terminal.

c) According the SD card's ID number, the terminal calculates the SD card key "k", and "Z′"according to the inverse formula $Z' = f_k^{-1}(X)$.

d) If "Z′" is equal to "Z", it means the SD card and terminal are "a couple", so the association process is complete.

The algorithm based on symmetric key is simple and secure, taking only three responses, and the key is never in the open environment.

Massive Services Authorization Based On Four Layers

Following the analysis of the service demand and security, there are four types of information to be encrypted: service data, ECM (Entitlement Control Message), EMM and the user key, so in this scheme the authorization is separated into four layers, see Figure 3.

ECM is created according to user groups. Users in close geographic proximity of each other with the same demands would be assigned the same key, so the ECM of different users will be the same. The broadcast channel is suitable for transmitting ECM to groups of users, which will save a lot of bandwidth (as it doesn't use the bi-directional mobile communications channel).

The EMM identifies the users and can be transmitted via the broadcast channel, without involving the mobile communications channel, preserving bandwidth and avoiding potential network congestions.

The fourth layer is the user key, which is the root key that encrypts the terminal product key to differentiate the users.

Analysis

According to the CMMB standard, the broadcast channel uses Orthogonal Frequency-Division Multiplexing (OFDM) as a method of encoding digital data on multiple carrier frequencies, and the Time Division Multiple Access (TDMA) channel-access scheme. The data frame is divided into different time slots, which carries a fixed number of bytes. So the data bandwidth of EMM is:

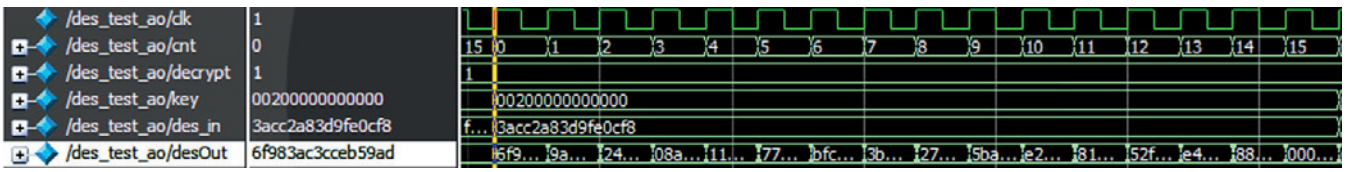

Figure 5: The ModelSim function verification

	ATTEMPT TIME	SUCCESS TIME	RATE
CHOSEN-KEY	10000	20	0.2%
DIFFERENTIAL	10000	15	0.15%
BRUTE FORCE	10000	2	0.02%

Table 1: Results of the simulated attacks on the scheme

$$B_{EMM} = \frac{L \times 8 \times N}{R} \quad (1)$$

where L is the number of bytes in the time slots, N is the number of users, and R is the data rate.

After our improvements, the data bandwidth of EMM is:

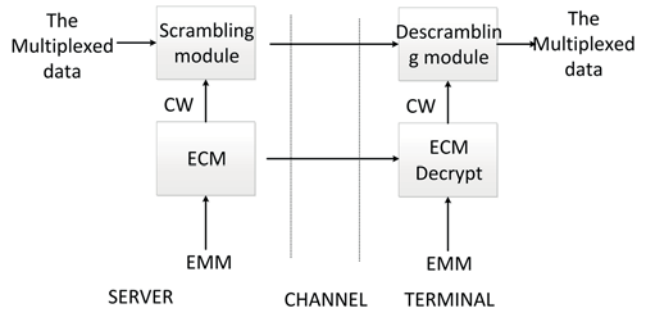

Figure 6: The test environment

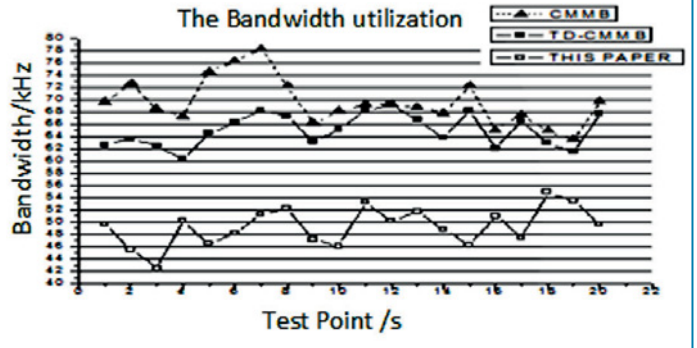

Figure 7: Bandwidth utilization by different mechanisms

$$B_{EMM} = \frac{L \times 8 \times N}{R * \lg G} \quad (2)$$

which increases the bandwidth by 10 log G, where G is the number of user groups.

In order to test and verify our scheme, we used the Modalism V10.1 simulation tool, Altera's Quartus V11.1 software and the DE2-115 development board that incorporates Altera's Cyclone IV FPGA. The circuit's RTL diagram is shown in Figure 4.

The information certification process is as follows:

1. The encryption key CW (Control Word) is generated by the random key generator.
2. The key stream generator receives the CW and uses it as root to the pseudo-random sequence generator.
3. Upon detecting the arrival of the services data, the control module XORs the pseudo-random sequence with the input data to generate the scrambling information.
4. At the same time, the counter begins to count.
5. After 400 counts (the number corresponding to the LBS (< 1m) and the data sent in 400 bits per cycle), the counter orders the control module to cycle the CW and start the next encryption process.

Figure 5 shows the verification of the SD card module, from authorisation and encryption to decryption. The test environment is shown in Figure 6.

The multiplexed data is then generated, and for simplicity, we assumed it to be a video stream.

The number of services requested by the users is set to N = 1,000,000, the cycle of the services key is 12 hours, and the traditional EMM bytes for one time slot are 37. The number of groups is set to 20. Bandwidth utilization according to the Monte Carlo statistical analysis is shown in Figure 7. It can be seen that the traditional CMMB mechanism has a level of 63.49-78.26, with an average of 69.5645 and square error of 14.5065.

The TD-CMMB mechanism has a level of 60.24-69.16, with an average of 65.0145 and square error of 7.09329. Our mechanism has a level of 42.49-54.93, average of 49.3145 and square error of 9.70518, showing a bandwidth improvement of log 20.

We also tested the security of our scheme with simulated attacks, consisting of the chosen-key attack, brute-force attack and differential cryptanalysis – each attempted 10,000 times. The results are shown in Table 1, with attempt success rates of only 0.2%, 0.15%, 0.02% for each type of attack respectively. ●

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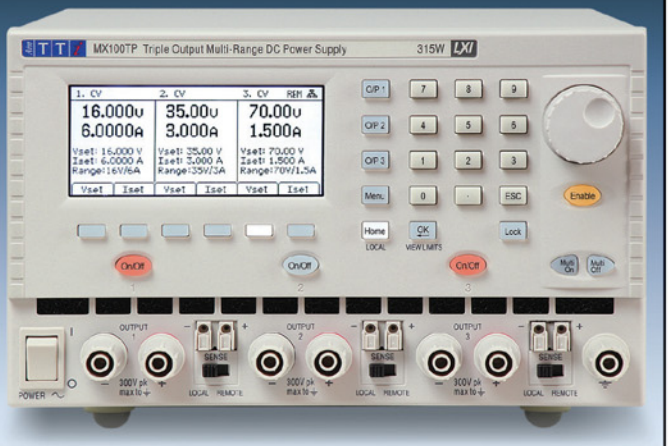

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High-Speed Signal Layout

MAURIZIO DI PAOLO EMILIO, HOLDS A PHD IN PHYSICS AND IS A TELECOMMUNICATIONS ENGINEER, PRESENTS THIS SERIES OF ARTICLES ON THE FUNDAMENTALS OF MICROELECTRONICS

PCB layout is one of the last steps in the design process and most critical. High-speed circuit performance is heavily dependent on the layout, and a high-performance design can be rendered useless because of poor or sloppy layout.

Technology

The PCB consists of several layers of metal and insulator. Copper traces connect the components; their shapes are an important aspect of the PCB, since they determine the PCB's inductance, capacitance and impedance. Resistance is generally ignored since most designs do not carry more than several milliamps of current, so the effects are usually negligible.

Figure 1: Stray capacitance

Typically, copper planes are used for power and ground. Planes make excellent high-frequency capacitors and are often used for high-frequency bypassing, complementing traditional capacitors. Usually, a solid ground-plane is preferred over a grid plane, since its inductance is minimal, which is desirable for high-speed signals, both analogue and digital. However, such a plane can cause capacitance problems at a circuit's sensitive nodes, so beware all its attributes and do not blindly use planes everywhere.

A good thermal factor of the PCB's material can help a solid plane act as a heat sink, which will keep thermal levels of all devices at a minimum; on the other hand, temperature-sensitive components should not be placed near the ground plane because of heat spread.

Vias are used in PCBs with high density of interconnections (i.e. BGA packages), to simplify trace routing around components. Usually, part of the PCB has passive components and very small vias. At high frequency, this can cause signal transmission problems; the easiest way to minimize them is not to use vias with signal traces (copper traces) at frequencies higher than 1MHz.

The density of current flowing through a conductor is particularly important when looking at the return path, as one way or another a current will find its way back to the source.

Techniques

High-speed circuit design techniques are very important, especially at frequencies above 1MHz. Some common errors occur due to capacitance. Ground planes help reduce inductance and create a bypass capacitor, but in the wrong place they can be disastrous to the system.

Another generic rule for high-speed circuit design is to use low value resistors. Using anything above several k-ohms is generally not recommended, because a parasitic capacitance as small as 1pF with a 10kΩ resistor can cause a pole (or, even worse, a zero) at 16MHz – a high frequency.

Finally, minimize trace lengths to avoid trace inductance, which can also cause instability, if in the wrong place.

Bypassing is essential to high-speed circuit performance. Capacitors at the power supply pins provide low AC impedance to ground and local charge storage for fast rising/falling edges; they also minimize transient currents in the ground plane.

A rule of thumb for placing capacitors close to the IC power input pins should be adhered to, otherwise, there can be too much inductance and a resonance effect can also occur, raising the impedance.

Typically, power and ground are on the inner layers of the PCB and must be brought to IC level through vias. Using multiple vias is highly recommended for both the power supply voltage and ground connections. Additionally, the vias should run to the capacitor and then to the IC, which forces current flow into the capacitor. Placing vias directly on the capacitor mounting pads can be an effective way of minimizing routing area and still achieve current flow routing.

Stray capacitance is a characteristic of transmission line impedance. In PCB design, a transmission line can be detrimental to the system and may cause noise in an amplifier with oscillation and/or decrease of signal amplitude.

To minimize stray capacitances, the ground plane should be separated from the signal trace, increasing the distance from the PCB's top layer and/or moving the ground plane below the signal trace. ●

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ELECTRONICA 2014

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The 26th International trade fair for electronic components, systems and applications – Electronica – will soon be opening its doors to welcome the electronics industry once again in Munich. This is a unique industry event presenting the state of the art in innovative electronics – a diverse range of components, pioneering hardware and software solutions and complete systems and applications, making it a must for anyone in the industry.

Why Visit Electronica?

In 2012, Electronica was visited by over 73,000 from 78 countries, with 2,669 exhibitors showing their products and services, and sharing their expertise.

This year, there will be a first-class programme, consisting of three international conferences, five forums, a CEO roundtable and over 200 lectures. Events will focuse on topics with dynamic innovative drive such as electromobility, energy efficiency and sustainability.

Electronica is seen as the decision-makers' trade fair, as some 89% of all visitors are decision makers, and 47% hold management positions. The fair received a rating of good to excellent for the scope and completeness of its exhibits (97% of visitors), for the presence of market leaders (95%) and for its character as a leading trade fair (95%).

Top-Class Program For 50th Anniversary

Electronica is celebrating its 50th anniversary this year. This year's focus will be on automotive, embedded systems, medical electronics and lighting, as well as the overarching themes of security and energy efficiency. The program of conferences and forums will explore these exhibition topics in greater depth.

According to analysis by the German Electrical and Electronics Manufacturers' Industry Association (ZVEI, www.zvei.org), the global market for electrical and electronic products grew by 3% last year to around 3.7 trillion euros, a growth driven mainly by the Asian and American markets. However, this has also benefited the German electrical industry, which in the first quarter of 2014 saw new orders rise by 3% over the previous year.

Electronica Automotive Conference

The Electronica automotive conference, supported by ZVEI, will take place on November 10 at the ICM – Internationales Congress Center München. The conference will investigate the major technology trends and strategies of the international automotive industry. Among the conference speakers are representatives of Audi, BMW, Daimler, Freescale, Infineon, Intel, Osram, Renesas and Visteon. This year, the focus is on lighting, sensor fusion and connectivity.

Embedded Platforms Conference

The embedded platforms conference will be looking for the second time at new technologies, concrete solution approaches and services for the development of embedded systems. The conference will take place on November 12 and 13, in parallel with Electronica, at the Press Centre East of the Messe München.

Wireless Congress

At the Wireless Congress 'Systems & Application' at the ICM (Internationales Congress Center Munich) on November 12 and 13, industry experts will discuss the technical aspects of current and future wireless technologies, primarily for industrial use.

Registration

To find out more about all these events, to register, as well learn how to get there, go to **www.electronica.de**

Electronica 2014 Preview For JTAG Technologies

JTAG Technologies will show an array of state-of-the-art products in Hall A1, on Stand 221, including its ProVision Software Suite, used to generate boundary-scan tests and in-system programming applications for assembled PCBs and systems. This professional development tool is fully automated and supports the import of design data from over 30 different EDA and CAM systems.

Two new products were added recently to the family of JTAG Live board debug tools: BuzzPlus and AutoBuzz. The original offering comprised three family members: Buzz, Clip and Script.

Hall A1, Stand 221
www.jtag.com

Seica At Electronica: Innovation, Automation and Optimization

This year Seica will show new test solutions for electronic boards focusing on innovation, automation and optimization. Three, fully-automated test systems will provide a comprehensive overview of Seica's VIP Platform, ranging from in-circuit to functional test, from flying probe test to standard, in-circuit test via a bed of nails, with specific focus on optical functional test for LED components.

A combined in-circuit-functional tester, the QUAD-JOB Compact SL will demonstrate high-speed board panel test for high-volume production environments.

Hall A1, Stand 459
www.seica.com

Standex-Meder Electronics Exhibits Sensors, Relays And Magnetics

Standex-Meder Electronics, a manufacturer of precise, reliable and long-lasting sensors and magnetic components, will exhibit a range of new and proven sensors, relays and magnetics, including its new KT Reed Relays, the MK28 Vane Sensor, the LS03-S Liquid Level Sensor, planar transformers and inductors, and more.

The KT series high-isolation reed relays are ideal for use in green applications, such as photovoltaic technology or hybrid vehicles.

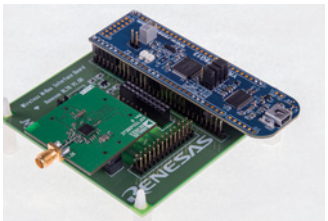
Hall B1, Stand 412
www.standexmeder.com

Solution Adds Communications to Metering Applications

Renesas Electronics Europe released the "Connect it! – Wireless M-Bus 868MHz" and "Connect it! – Wireless M-Bus 169MHz" solution kits, which it will also show at the Electronica fair this year. These platforms enable engineers to save time by re-using existing Wireless M-Bus solutions to add communications capabilities to their metering applications.

Wireless M-Bus is fast becoming a standard for bringing communication to existing metering applications, from heat cost allocators to gas and water meters. Being able to remotely collect meter readings is universally recognized.

Hall A6, Stand 243
www.renesas.eu



Tektronix Shows The World's First 6-In-1 Oscilloscope

Tektronix has released a number of exciting new test and measurement solutions, that will help users discover, capture and test faster, and these solutions will be shown at the Electronica show in November.

Highlights include: The MDO3000 Series; The TBS1000B-EDU Series; and the Keithley Parametric Curve Tracer Configurations on the 2600-/4200-PCT Series, recently enhanced with the new High Power Interface Panel Model 8020; among others.

In addition visitors to the Tektronix stand will be able to participate in a prize draw to win an MDO3000.

Hall A1, Stand 668
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Extended Product Portfolio From Rigol At Electronica

Rigol Technologies will present several new products in the field of oscilloscopes, analyzers and test software at this year's Electronica. This will complete Rigol's portfolio with praxis-orientated and cost-effective products. There are two new models of the successful DSA800 Spectrum Analyzer Series as well as the new Mixed Signal Oscilloscopes (MSO) and a PC Software to perform standard measurements e.g. on switching power supplies.

The DSA832 and DSA875 expand the DSA800 Spectrum Analyzer series to 3.2GHz and 7.5GHz respectively.

Hall A1, Stand 259
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THIS SERIES PRESENTS SOME SIMPLE ARDUINO PROJECTS. ARDUINO IS AN OPEN-SOURCE ELECTRONICS PROTOTYPING PLATFORM, BASED ON FLEXIBLE, EASY-TO-USE HARDWARE AND SOFTWARE

Calibrating A Light Sensor With The Arduino

BY **JOHN NUSSEY**

By calibrating sensors on the Arduino project, they can be tailored for their location. In this example, I present how to calibrate a light sensor.

Light, of course, is highly variable, whether inside, outside, in a well-lit room, or a candlelit one. Despite the huge variation, all these ranges of light can be sensed and interpreted by the Arduino, as long as it knows the range.

The following sketch explains how to calibrate a light sensor to its surroundings. Completing the circuit calibrates the light sensor automatically.

The following is needed for this project:

- An Arduino Uno;
- A breadboard;
- An LED;
- A light sensor;
- A 10kohm resistor;
- A 220-ohm resistor;
- Jumper wires.

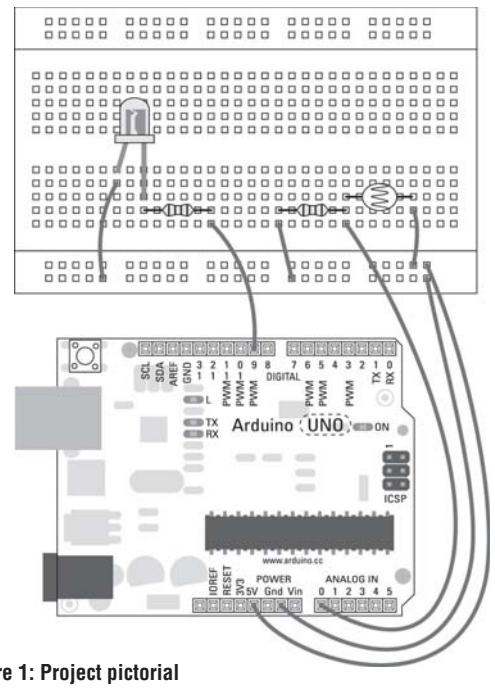


Figure 1: Project pictorial

Build the circuit and go to File→Examples→03. Analog→Calibration to find the sketch. The code for this example is shown below.

Calibration

Here is one technique for calibrating sensor input. Sensor readings during the first five seconds of sketch execution define the minimum and maximum of expected values attached to the sensor pin.

The sensor minimum and maximum initial values may seem backwards.

Initially, you set the minimum high and listen for anything lower, saving it as the new minimum. Likewise, you set the maximum low and listen for anything higher as the new maximum.

The Circuit:

```
* Analog sensor (potentiometer will do) attached to
  analog input 0
* LED attached from digital pin 9 to ground

created 29 Oct 2008
By David A Mellis
modified 30 Aug 2011
By Tom Igoe

http://arduino.cc/en/Tutorial/Calibration

This example code is in the public domain.

*/
// These constants won't change:
const int sensorPin = A0; // pin that the sensor is
attached to
const int ledPin = 9; // pin that the LED is attached to

// variables:
int sensorValue = 0; // the sensor value
int sensorMin = 1023; // minimum sensor value
int sensorMax = 0; // maximum sensor value
void setup() {
```

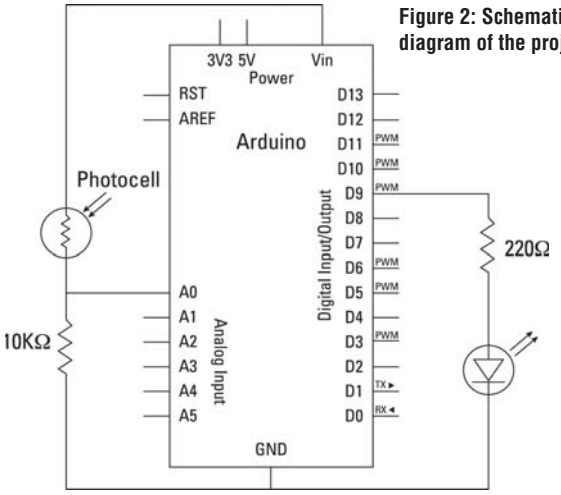
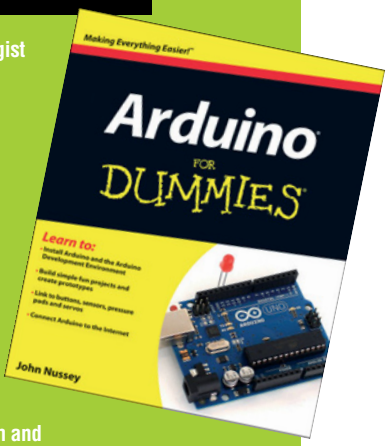


Figure 2: Schematic diagram of the project

WIN THE 'ARDUINO FOR DUMMIES' BOOK BY JOHN NUSSEY

John Nussey is a creative technologist based in London. He teaches interaction design and prototyping at the Goldsmiths College and the Bartlett School of Architecture among others.
We have a couple of copies of this book to give away. To enter please supply your name, address and email to the Editor at svetlanaj@sjpbusinessmedia.com.
The winner will be drawn at random and announced at the end of the series.




```
// turn on LED to signal the start of the calibration period:

pinMode(13, OUTPUT);
digitalWrite(13, HIGH);

// calibrate during the first five seconds
while (millis() < 5000) {
sensorValue = analogRead(sensorPin);

// record the maximum sensor value
if (sensorValue > sensorMax) {
sensorMax = sensorValue;
}

// record the minimum sensor value
if (sensorValue < sensorMin) {
sensorMin = sensorValue;
}
}

// signal the end of the calibration period
digitalWrite(13, LOW);
}

void loop() {
// read the sensor:
sensorValue = analogRead(sensorPin);

// apply the calibration to the sensor reading
sensorValue = map(sensorValue, sensorMin, sensorMax, 0, 255);

// in case the sensor value is outside the range seen during calibration
sensorValue = constrain(sensorValue, 0, 255);

// fade the LED using the calibrated value:
analogWrite(ledPin, sensorValue);
}
```

Upload the sketch and let Arduino settle to the normal, ambient light levels for five seconds. Then try moving your hand over it; you should find it a lot more responsive than it is when it's just reading the analog value normally, and the LED should have a range from fully on, when it is open, to fully off, when it is covered. ●

More on this and other Arduino projects can be found in the John Nussey's book 'Arduino For Dummies'.

THE INTERNET OF THINGS WEBINAR –

CONNECTIVITY MAKES THE WORLD GO AROUND

In cooperation with RS Components

Friday 26th September 2014

www.electronicsworld.co.uk/events/webinars

The Internet of Things (IoT) promises to connect all devices to networks, easily accessible and offering a wealth of information. Analysts forecast some 26 billion devices connected to the Internet by 2020, each with its own unique ID. In preparation for the IoT era, sensors, microcontrollers and many other electronic devices are being developed and launched.

Electronics World in conjunction with RS Components addressed this issue with a dedicated webinar, which took place at the end of September. The webinar can be viewed at **www.electronicsworld.co.uk/events/webinars**.

It was hosted by Alexandra Deschamps-Sonsino of Designswarm, product and interaction designer, and entrepreneur (see box).

Here she addresses a few outstanding questions, relating to this subject, complementing the webinar presented in September.

Q: How do you think the Internet of Things will change in the next five years?

There's a lot of uncertainty and excitement at the minute, quite beyond Gartner's Hype Cycle analysis this year. Many investments are falling flat of expectations as startups realise how hard it is to get market adoption of new types of devices. Wearables find little "sticky-ness" and short-lived interactions. Startups try their luck with crowd-funding, and find little success or get burnt out trying to find further funding after campaigns that are too small. All these challenges will probably have disappeared by the time 2022 comes along. We'll have a niche but growing community of investors who will be interested in long-term returns. We'll also possibly have digital tools to help someone plan adequately for manufacturing and product development. We may even see a price drop on things like certification and design to manufacture processes that might become entirely digital. I hope beyond anything else that we will see consensus emerge in the industry around communication technologies which allow the most creativity and lowest cost to creative minds.

Do you think privacy is dead in the Internet of Things?

I don't think privacy is dead just like privacy isn't dead on line. It's simply changing. Our idea of privacy is also reasonably new, after thousands of years living in villages and ten people per household. As we became more urban our ability to isolate ourselves from others increased. The Internet has broken those barriers down again but also exposed our location, actions and thoughts to others for the benefit of advertisers and the NSA. With the Internet of Things, new data can create new insight into our lives, unless we are able to fully control the conversation we have with our technology providers.

The EU (**http://www.internet-of-things-research.eu/**) is introducing recommendations on this matter, which will help create some ethical barriers and obligations for companies to give consumers tools to control and protect their privacy. This is really great and I think the UK should lead on this too.

Who are the emerging players in the industry?

Companies who traditionally have been digital only are recognising the potential of physical objects, token or urban experiences as a way to extend their offering. This will really represent a sea change when it comes to IoT soon. Companies like Paypal, Google and Facebook are currently only dipping their toes into the Internet of Things with flashy acquisitions, but once knowledge is transferred, you can be sure that retail experiences will change with their help.

ABOUT ALEXANDRA DESCHAMPS-SONSINO

Alexandra Deschamps-Sonsino has been named second in the Top 100 Internet of Things Thought Leaders (Onalytica, 2014) and is in the 2014 Top 100 Influential Tech Women on Twitter (Business Insider).

Since 2006, she has built consumer-facing Internet of Things products, services and communities for clients such as BBC R&D, Nokia, British Gas, EDF and British Telecom.

She is the co-founder of IOT Angels, a UK-based angel network focusing on Internet of Things investments, and co-editor of Connected, a quarterly publication on the Internet of Things. Alex is also credited as founder of the Good Night Lamp, offering a range of Internet-connected lamps.

She has been running the London Internet of Things meetup for Xively since 2011. It is the largest meetup in the world dedicated to this topic.

With a B.A.Sc. in industrial design from the Université de Montréal and an M.A. in Interaction Design from the Interaction Design Institute Ivrea, her work has been exhibited at the Museum of Modern Art in New York, the Victoria & Albert Museum in London and galleries around the world.

Do you think standards will slow down the development of the industry?
Not right away as there are many ways to connect to the Internet. Zigbee may or may not be on the way out, Bluetooth Low Energy certainly has an advantage because of its ubiquity, but GSM is presenting interesting opportunities for startups (my own, the Good Night Lamp is working with Eseye's M2M platform) with customers who need zero setup and global coverage for their product experiences.

Are there any formal courses to guide through IoT implementation?
There aren't really any formal training courses available beyond beginner Arduino and Raspberry Pi. You may, if you're starting from the very beginning, choose to take a class at 'Technology will Save Us' **http://technologywillsaveus.org/**, **http://codasign.com/** or go to Does Liverpool and attend one of their workshops and events.

What impact can Internet of Things have on the emerging market of renewable and power grid?
The reasons why the Internet of Things isn't called the Intranet of Things is really about being able to adopt an open and APIable way to address hardware. For renewables, we should be building those PV cells and small windmills cheaply and easily with a view to being able to control them and sell power to the national grid when we should/want to. Developing an ecology of white goods that are controlled by our garden windmill would be amazing, so being to "plug" into it will make innovation happen quickly. This will really show the market what it means to live in a more sustainable future home without costly setup and investment.

Do you see the future of IoT devices in proprietary or open source developments?
Open source is at the heart of the Arduino community and that platform has really led the way when it comes to prototyping devices for the mass market. There is currently no good way to sell that to investors but perhaps the new IoT entrepreneurs in the next few years won't need the same types of investors that funded apps and websites.

Is hardware now something that a VC will invest in at this time?
In the UK, sadly it's still too early to say we have all the pieces in place to have a rich and active investment ecology. I'm trying to address that with IOT Angels, a series of Master Classes on the Internet of Things for investors. The UK certainly has a history of investing in hardware if the numbers are there, which sadly is usually in industrial or B2B applications. Most IoT startups are in the consumer space and the lack of financial support means that those companies will need to prepare to be financially independent for a long time.

With the amazing consultancy BERG recently closing, what do you think is the best way for designers to work in the field of connected objects for the future?
I don't think BERG should be seen as an example of failure, they were doing something quite unique but tricky. Part toy, part printer, part industrial offering, Little Printer and bergcloud were really companies with the budget of a startup. There's plenty of space for designers to become the founders of startups because – unlike technologists – they will often have a user-centered view of opportunities and product development, and everything we know about successful companies points to those characteristics as being highly desirable.

How can we be more professional than hobbyists in IoT?
There're plenty of incubators that will open up in the UK in the next months to turn an idea into a company but the first thing is to go to a meetup and meet people who would want to collaborate with you on your idea. Traditionally incubators accept teams and not lone founders.

Is brainwave involvement in anyway related to the IoT, like controlling events using brainwaves?
Drones, brainwaves and limited functionality wearables don't excite me particularly. They don't respond to user needs but rather try to sell you into strange behaviours that can never really become habit and integrate into people's lives.

Why did RS get involved?
RS launched an Internet of Things (IoT) themed area hosted under Design Centres via its online DesignSpark community DesignSpark community to act as a knowledge base to aid engineers designing IoT-enabled applications. The Design Centre includes an introduction to the IOT and includes the latest blogs and a series of articles written by partners, DesignSpark community members and leading Industry experts including Alexandra Deschamps-Sonsino of Designswarm. It focuses on a detailed break-down of the IoT and a look at how it all started, where it's heading and why we need it, exploring how "Things" connect from hardware to applications, network infrastructure and security of data.

View the free on demand webinar at
www.electronicsworld.co.uk/events/webinars

ABOUT DESIGNSPARK.COM

Designspark.com is the gateway to online resources and design support for engineers, powered by RS Components. It hosts a technology hub of videos, blogs and technical information on industry trends and emerging technologies.

DesignSpark has been a community at the forefront of providing updated information on the latest industry trends and the IoT Design Centre at DesignSpark aims to set the wheels in motion for discussions around best practice and recommendations for products suitable for use in IoT applications.

FACTORY-PROGRAMMED LINEAR HALL-EFFECT SENSOR IC

The new A1366 from Allegro MicroSystems Europe is a factory-programmable linear Hall-effect current sensor IC designed to achieve high accuracy and resolution by the use of advanced temperature compensation technology.

The proprietary linearly interpolated temperature compensation technology, programmed at the Allegro factory, provides sensitivity and offset that are virtually flat across the full operating temperature range. Temperature compensation is carried out in the digital domain using integrated EEPROM technology without sacrificing the analogue signal path bandwidth.

The A1366 is a ratiometric Hall-effect sensor IC which provides a voltage output that is proportional to the applied magnetic field. The factory programming of the sensitivity and quiescent (zero field) output voltage gives a typical accuracy of less than ±1% over the full operating temperature range. Its high-frequency operation makes it ideal for use in hybrid electric vehicle inverters, DC-to-DC converters and electric power steering applications, although it is equally suited to any current sensing system requiring high-bandwidth operation.

www.allegromicro.com

SENSIRION AT THE COMPAMED 2014 TRADE FAIR

Sensirion will exhibit at COMPAMED in Hall 8a, booth H19.6 its innovative products. At this year's COMPAMED trade fair, there will be new and enhanced sensor solutions for measuring gas and liquid flow rates and differential pressure on show.

Sensirion's new, disposable, liquid flow sensor solutions for medical devices are intelligent, compact and cost-effective, promising to change drug delivery from the ground up and offer safer, more reliable and more mobile solutions for care in hospitals as well as the home.

Sensirion's new SFC5000 digital mass flow controller enables mass flow to be measured and controlled rapidly and precisely with long-term stability over a wide dynamic measuring range. This makes the sensor ideal for medical applications such as mixing gases in anesthetic devices. Thanks to Sensirion's CMOSens technology, the new SFC5000 offers maximum precision, repeatability and reliability at a highly attractive price.

In addition, on show will be the compact, precise and quick SFM3100 analog mass flow meter, also new from Sensirion.

www.sensirion.com

ROHDE & SCHWARZ AND HAMEG OFFER HMO3000 COMPLETE BUNDLE AT A LOW PRICE

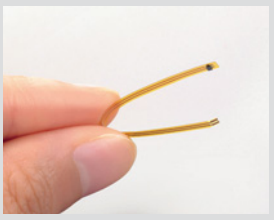
Rohde & Schwarz has put together an attractive T&M equipment bundle: a specially priced HAMEG HMO3000 mixed signal oscilloscope (MSO) plus two logic probes with all the available software options. Anyone thinking about purchasing a new oscilloscope should act fast to save up to 40%, depending on the selected model. The promotion only runs until December 31, 2014.

The offer applies to all two- and four-channel HMO oscilloscopes from its subsidiary HAMEG Instruments. The Complete2 bundle includes the two-channel 500MHz HMO3052, and Complete4 contains the comparable four-channel HMO3054. At no extra charge, the Munich-based electronics specialist adds two HO3516 8-channel digital probes with a sampling rate of 1 Gsample/s for analyzing up to 16 logic channels. The two logic probes are not tied to a specific instrument and can be used with any other HMO oscilloscope. To complete this attractive bundle, the HO010, HO012 and HO014 software options are also included.

http://shop.rohde-schwarz.com

LOW PROFILE FLEXIBLE FILM TEMPERATURE SENSORS IDEAL FOR WEARABLE PRODUCTS

Murata is starting the mass production of a range of surface-mounted NTC temperature sensors that are packaged on a flexible printed circuit (FPC) film. With an FPC thickness of approximately 100um, they can be easily routed inside complex designs and tight spaces. Owing to their low heat capacity, the sensor's thermal responsiveness is excellent.



Measuring 50.00 x 3.17 x 0.55mm, the sensors are ideal for sensing the housing temperature of smartphones and tablets. They are also very suitable for use in wearable products for sensing body surface temperature.

The FTNT55XH103FA1A050 sensor can measure temperatures in the range of -40 to + 125 degrees C. Resistance at 25 degrees C is 10kohm ±1%.

As smartphones and tablets have become more compact with even greater sophisticated functions, the need to monitor the thermal characteristics in space-constrained designs has become even more important.

www.murata.com

FUTURE FACILITIES ANNOUNCES RELEASE 9 OF 6SIGMAET SIMULATION TOOL

Future Facilities announced a significant update to 6SigmaET, the company's powerful, intuitive and easy-to-learn thermal simulation tool for use by designers of electronic components and products.

Release 9 of 6SigmaET integrates a new CFD (Computational Fluid Dynamics) solver that radically speeds up thermal simulation, as well as introduces a number of enhancements to the tool's functionality and user interface.

Thermal simulation is a tool that allows engineers to assess the thermal performance of their designs and efficiently manage the heat generated by electronic components and assemblies. A better understanding of the temperature distribution in an electronic system can be used to fine-tune designs and enable the creation of products that are ever smaller and more reliable. The technology can also significantly cut product development time by reducing design iterations and ensuring that a final product operates within its required thermal parameters, enhancing operating life and reliability.

www.6sigmaet.info

VTAC HIGH-SPEED DATA CONNECTORS FOR VPC MASS INTERCONNECT SYSTEMS

Now available in the UK from the Peak Group are a range of VTAC High Speed Data (HSD) connectors for the Mass InterConnect systems produced by Virginia Panel Corporation (VPC).

Designed for use in high-speed testing, the new connectors offer data transfer rates of over 10Gbit/s per differential pair. Rapid data transfer is ensured when the connectors are installed in VPC's 90 Series module, which can support up to 34 VTAC HSD connectors with two differential pairs or four single-ended connections.

VTAC's HSD contacts are gold-plated for signal integrity and maximum reliability, and are compatible with several industry standard connectors including: USB 3.0, Serial ATA, HDMI, DVI and DVI-1, RJ45 Gigabit Ethernet, QSFP and Infiniband for all high-speed testing requirements.

Applications include high-speed testing in industries such as telecommunications, military and medical electronics.

www.thepeakgroup.com

CITIZEN USES LATTICE ICE40 FPGA FOR THE FASTEST SATELLITE-SYNCHRONIZING WATCH

The iCE40 FPGAs from Lattice Semiconductor are at the heart of Citizen Watch's Eco-Drive Satellite Wave F100 wristwatch, an innovative fusion of technology and aesthetics that receives and processes satellite signals in real time to display the correct time anywhere in the world's 40 time zones.

"Lattice's solution provided the smallest form-factor for processing data received from GPS satellites and computing precise time, faster than any processor for running our custom algorithms and without the need to develop an ASIC," reported Citizen Watch.

The iCE40 FPGA rapidly picks up the precise time from the input data of the GPS satellite signal receiver and generates the control signals to adjust the watch to the correct time.

www.latticesemi.com/iCE40

CAPZERO X-CAPACITOR DISCHARGE IC CERTIFIED TO NEW IEC 62368 STANDARD

Power Integrations announced that its CAPZero family of innovative, two-terminal, automatic X-capacitor discharge ICs has been certified to meet IEC 62368, the new over-arching safety standard covering TVs and IT equipment. The CAPZero family eliminates power losses while allowing power supplies to comply with safety standards. The new standard replaces IEC 60950 and IEC 60065 and will become mandatory.

CAPZero ICs are smart, high-voltage switches, placed in series with the resistors used to provide a safe discharge path for a power supply's X capacitor. Without this switching mechanism, these discharge resistors cause a constant power drain while AC is connected and as such contribute significantly to no-load and standby input power consumption. CAPZero X-capacitor discharge ICs block current flow to the discharge resistors when AC voltage is applied, cutting the power wasted in these components to zero. When the AC voltage is disconnected, CAPZero automatically and safely discharges the X capacitor.

www.powerint.com

NEW DC-LINK FILM CAPACITOR SERIES WITH SNAP-IN TERMINALS

AVX launched a new FRC series of medium power DC-link film capacitors, with a wide range of capacitance and voltage values in addition to self-healing properties.

Designed for use in DC filter circuits, power supplies, industrial inverters, UPS systems, motor drives, power converters and solar inverters, the FRC series capacitors comprise of dry, wound, metalized polypropylene film dielectric encased in a size A, self-extinguishing, cylindrical plastic case sealed with thermosetting resin and featuring four snap-in terminals that facilitate easy mounting to PCBs.

The FRC series capacitors are available in nine voltages spanning 400V-1500V, two tolerances (±5% and ±10%), two lead lengths (4mm and 8mm) and with capacitance values spanning 4.7-35µF. Housed in size A cylindrical cases measuring 54mm (L) x 36mm (OD) x 5.1mm (P1), the RoHS-compliant series is rated for operating temperatures spanning -40°C to +105°C and exhibits long lifetime performance of 100,000 hours at the rated voltage and 70°C.

www.avx.com

EZ-BOARDWARE PCB CONTACT FROM HARWIN IS SECURE AND COST-EFFECTIVE

Harwin has expanded its popular EZ-BoardWare PCB socket portfolio with a new contact that can accommodate mating pins ranging from 0.8-1.5mm in diameter. The new products complement an existing range, enabling Harwin to offers parts with pin diameters from 0.8-1.8mm.

A cost-effective alternative to turned PCB sockets, EZ-Board sockets are designed for SMT assembly and are ideally suited for high-volume applications. The components come in industry-standard tape and reel packaging, enabling them to be automatically placed, which minimizes installed costs.

The new contacts are stackable on 2.54mm pitch spacing. The design features a two point contact system which ensures secure retention, whilst facilitating easy removal and replacement of the socketed component.

Ideal for contact pins, discrete components, sensors etc, the new EZ-Board sockets will suit applications in many mid- to high-volume markets, ranging from consumer electronics through to industrial, instrumentation and control systems environments.

www.harwin.co.uk

GaN SYSTEMS AND MOUSER ELECTRONICS SIGN AN EXCLUSIVE WORLDWIDE DEAL

GaN Systems announced an exclusive worldwide distribution agreement with Mouser Electronics. GaN Systems's gallium nitride power transistors are based on its proprietary Island Technology and offer significant advantages over traditional silicon MOSFETs and IGBTs to bring smaller, lighter and more efficient power electronics to numerous applications, including consumer appliances, data centre server racks, heavy duty battery-operated power tools, notebook travel adaptors and many others.

GaN Systems's Island Technology IP incorporates the wide bandgap and superior switching speed, temperature, voltage and current performance of gallium nitride into a unique structure that maximizes wafer yields and produces highly efficient transistors, up to four times smaller and at lower cost than tradition design approaches. In order to take advantage of the Island Technology devices' intrinsic fast switching and dense current carrying capability, GaN Systems also designed GaNPX packaging, which has no wire bonds, minimizing inductance and thermal resistance and increasing reliability.

GaN Systems

MOUSER ELECTRONICS LAUNCHES FREE DESIGN INTEGRATION TOOL MULTISIM BLUE

Mouser Electronics launched a PCB design integration tool MultiSIM BLUE, designed in collaboration with National Instruments (NI). The powerful tool is available free globally, offered in English, German and Chinese.

This all-new PCB design integration tool utilizes the Berkeley SPICE engine and includes a preloaded component library of over 100,000 frequently-used components from multiple Mouser databases. MultiSIM BLUE facilitates real-time bill-of-materials (BOM) price quotes and component database updates enhance the creative design engineering efficiency. The tool supports pre-layout design convergence analysis and mixed-signal simulation and can handle components as complex as BGAs with over 1000 pins on pin pitches down to 0.8mm. MultiSIM BLUE also provides a 3D visualization of the PCB with no limits on the shape and size of the PCB, thereby enabling innovative, forward-looking design.

MultiSIM BLUE has an array of features: it supports operating systems running on Windows XP, 7, 8, as well as Vista.

www.mouser.com

IDT INTRODUCES RF SWITCH WITH ULTRA-HIGH ISOLATION AND LINEARITY

Integrated Device Technology (IDT) introduced the F2912 switch, the first in a line of new radio frequency (RF) switch products planned by the semiconductor company. The F2912 has an industry leading combination of low insertion loss, and high isolation and linearity, making it an ideal choice for base stations (2G, 3G and 4G), microwave backhaul and front haul, test equipment, CATV head-end, WiMAX radios, wireless systems and general switching applications.

The F2912 supports the latest system requirements for multiple applications with features that include:

- Frequency range of 300kHz to 8GHz, achieving broad bandwidth without sacrificing performance across the entire frequency range;
- Low IL of 0.4dB, providing low path loss without compromising isolation performance;
- High isolation of 60dB at 2GHz to reduce signal leakage between adjacent RF port paths;
- High OIP3 of +64dBm to reduce intermodulation distortion;
- P1dB of 30dBm, providing 1W compression point, ensuring rugged operation for a variety of applications.

www.idt.com

SUNON FANS NOW AVAILABLE IN IP68 VERSION

Dedicated to harsh environments, the Sunon IP68 version fans are protected against heavy dust and incoming water. Three models are already available and have had UL/TUV certification.

To get the IP68 certification level, Sunon engineers developed a complete potting process coating for the motors of the IP68 fans, whereas usual models have glue coating or conformal coating. This specific moulding process covered 100% of the stator, coil, circuit and wire by shaped resin, preventing the system from dust and water intrusion. Anti-rust treatment (salt spray protection) is also available as an option.

Several tests have been conducted with success under extremely dusty and wet conditions: eight hours under a maximum depression of 2kPa, one hour less than 1m of water.

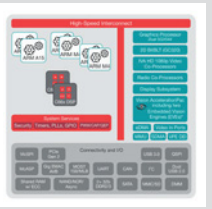
Sunon IP68 fans are dedicated to harsh environment applications, like outdoor telecom, solar farms inverters, factories, onboard automotive, outdoor LED lightings and others.

Customization is possible on demand for large series.

www.sunon.com

TI STRENGTHENS DSP AND VISION PROCESSING ON ITS JACINTO FAMILY OF PROCESSORS

Texas Instruments (TI) is adding signal processing functionality to its new DRA75x processors to enable customers to augment infotainment and pair informational advanced driver assistance systems (ADAS) features. The combination of these two will allow customers to produce cars with digital cockpit integration as well as traditional infotainment features without compromising performance.



The new DRA75x processors, Jacinto 6 EP and Jacinto 6 Ex, both using the same architecture as other Jacinto devices, enable automotive manufacturers to scale their investment without additional R&D or significant bill-of-materials (BOM) increase to deliver a diverse portfolio of products with hardware and software compatibility.

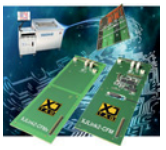
Jacinto 6 EP is a processing leader in the infotainment segment with 1.4GHz of digital signal processor (DSP) performance equivalent to 22GFLOPS/60GMACS. Complete with all the features of the Jacinto 6, the Jacinto 6 EP device provides additional peripherals and DSP horsepower to add features while controlling system cost.

www.ti.com

XJTAG RELEASES BOUNDARY SCAN FOR TERADYNE TESTSTATION

XJTAG, a supplier of boundary scan technology, released new XJLink2-CFM and XJLink2-CFMx modules that provide Teradyne users with integrated access to XJTAG's powerful test and programming tools, operating under the control of the TestStation test program.

With a JTAG solution installed internally to the TestStation In-Circuit Test System, the complexity and recurring cost impact of fixture-based test can be significantly reduced, while improving the overall test coverage.



Integrated Teradyne access will provide the following:

- Advanced JTAG control using available slots on a Teradyne Multi-Function Application Board;
- Use of the same tests in production line ICT and bench-top repair;
- In-system programming of Flash, FPGA and CPLD devices;
- Multi-protocol support – including SPI and I²C.

This new integrated product enables streamlining of the production line, while also boosting fault coverage, thanks to the combination of XJTAG's advanced connection test and non-JTAG device testing/programming with Teradyne's In-Circuit Test capabilities.

www.xjtag.com

RS COMPONENTS ADDS 3D SYSTEMS PROJET 1200 TO ITS RANGE

RS Components (RS) has added the small-format production-quality micro-SLA ProJet 1200 from 3D Systems to its range of rapid-prototyping 3D printers.

The ProJet 1200 low-cost professional-grade printer is the first product in the RS 3D printer range to use stereolithography (SLA) technology, which delivers a smoother finish and builds layers that are less visible compared to alternative low-cost 3D printer technologies such as Fused Filament Fabrication (FFF).

In addition to building prototype concepts, the ProJet 1200 is ideal for small, precise and detail-rich casting patterns. Factory calibrated for reliable and accurate operation, the micro-SLA ProJet 1200 integrates enhanced LED DLP (Digital Light Processing) laser technology to print 30-micron (0.03mm) layers at a resolution of 56 microns (effective 585dpi), which results in extremely fine feature detail and smoothness and makes it suitable for building production components such as electronic connectors. The printer also boasts a diverse range of uses outside of engineering markets.

www.rs-components.com

MOST ADVANCED, BROADEST VENDOR AUTOSAR SUPPORT ON INTEGRITY RTOS

Green Hills Software, an independent software supplier for the Internet of Things, now offers the industry's most advanced integration and broadest AUTOSAR vendor support for AUTOSAR application development, debug, execution and deployment. Green Hills Software's unique approach for advancing the use and deployment of AUTOSAR in automotive electronics is based on the embedded industry's safest real-time operating system, INTEGRITY.

There is a broad and growing adoption for the use of AUTOSAR in automotive electronics. The automotive processors targeted for executing AUTOSAR applications and services are more complex and more powerful than previously used. With this comes an increasing challenge to manage application complexity, debuggability and function freedom from interference.

Green Hills Software's unique approach to supporting the development and use of AUTOSAR in automotive electronics delivers the industry's only AUTOSAR and processor vendor neutral solution for combining legacy OSEK, legacy AUTOSAR and/or new AUTOSAR applications and services safely and reliably into a single ECU.

www.ghs.com

PROTEUS 25

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1990 Schematic capture added

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1992 Topological route editing
1993 Fully integrated circuit simulation
1994 Rip up and retry autorouter
1995 Shape based power plane support

True mixed mode SPICE simulation 1996
Interactive simulation 1997
PIC® microcontroller simulation 1998
8051 microcontroller simulation 1999
World 1st MCU co-simulation 2000

2001 Language support for MCU simulation
2002 Electra adaptive shape based router
2003 World 1st 32 bit MCU support with ARM®-7
2004 Integrated Proteus VSM and MPLAB™
2005 Redesigned GUI across Proteus Suite

3D visualisation engine 2006
World 1st USB simulation 2007
HDL support in simulation 2008
Shape based autorouter included 2009
VSM Studio IDE introduced 2010

2011 Design rule aware manual routing
2012 ARM® Cortex™-M3 MCU simulation
2013 New application framework

2014

NEW Project clips enable re-use of blocks of circuitry inside a project across multiple projects
NEW Dynamic teardrop control including per pad override
NEW Integrated Arduino™ toolchain with VSM Studio and common Arduino™ shields
NEW Library import tools (BSDL,PADS ASCII)
NEW New Project notes module for generic entry of notes and reports
NEW Major upgrade to BOM module to improve physical output and simplify styling
NEW Improved support for paste, solder, fanout and stitching vias during footprint creation

Labcenter Electronics www.labcenter.com

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