# HIRP OPEN 2016 (Canada)

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1. **Background and Motivation**

Google has just released a novel universal compression engine Brotli aiming to replace the common deflate algorithm. Brotli can achieve better compression ratio and decompression speed with slight degradation in compression performance. Data compression is a basic technology in ICT industry, which provides broader bandwidth and better storage efficiency. It is a good opportunity for Huawei to compete for the next-generation compression standard.

2. **Scope**

   Design a novel compression algorithm which is suitable for FPGA implementation (memory friendly, parallel and pipeline). The software implementation should have 2X decompression speed and 1.3X compression ratio relative to deflate without compression speed degraded.

3. **Expected Deliverables**

   - Technical report
   - Documentations of algorithm details and data structures.
   - C/C++ Source code

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1. **Background and Motivation**

   In order to reduce the overhead in storage space, massive data are stored in compressed format. However, applications must decode the compressed data before operating on them, which causes both CPU overhead and performance degradation. Therefore, operating directly on compressed data can be a new feature for compression algorithm design to alleviate the performance degradation, such as IBM DB2 BLU Accelerator.

2. **Scope**

   Design a novel format for compression algorithms to allow applications(such as database, graphic storage and so on) to operate COUNT/LOCATE/DISPLAY directly on compressed data with O(1) time complexity and less than 10% reduction of compression ratio relative to deflate.
3. Expected Deliverables

Technical report
Documentations of algorithm details and data structures.
C/C++ Source code

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1. Background and Motivation

Image (JPEG) and Video (H.26x, MPEGx) files cost the most storage space in the modern data-centers. If these multi-media files can be compressed lossless further with acceptable memory and throughput, the cost of storage can be degraded. Algorithms like PAQ8PX, Stuffit and packJPG focus on lossless JPEG compression, but their throughput is low, and some of them cost too much memory.

2. Scope

Design/Optimize an algorithm for lossless multi-media compression (start with JPEG), with 1GBps full duplex compression/decompression throughput on the state-of-art FPGA and above 30% space saving.

3. Expected Deliverables

Technical report
Documentations of algorithm details and data structures.
C/C++ Source code

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1. Background and Motivation

The PAQ family achieves the best compression ratio in many Benchmarks of lossless data compression. These algorithms always cost a lot of memory with low throughput, and they have multiple context-mixing models. If we know which model in the PAQ family suits for the specific kind of data, and rebuild an efficient high-throughput algorithm, it will become practical and help to solve many lossless compression problems.
2. **Scope**

The method of translating the PAQ family to an efficiency high-throughput algorithm on specific data. We will test the result with the network transmission messages, with some Gzip and JPEG compressed payload. 10%~20% compression ratio degradation is acceptable for the translation. For example, we compress the data with PAQ8 and achieve 50% compression ratio, the high-throughput algorithm's ratio is between 55%~60%. The high-throughput algorithm can be applied well on FPGA and achieve 5~10GBps throughput on the state-of-art FPGA.

3. **Expected Deliverables**

Technical report
Documentations of algorithm details and data structures.
C/C++ Source code

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1. **Background and Motivation**

Memory compression is a memory management technique that utilizes data compression to reduce the size or number of paging requests to and from the auxiliary storage. By reducing the I/O activity caused by paging requests, virtual memory compression can produce overall performance improvements.

2. **Scope**

Design a memory compression algorithm which is suitable for FPGA implementation (parallel and pipeline). The software implementation should have over 50% performance improvements relative to the scenario without compression.

3. **Expected Deliverables**

Technical report
Documentations of algorithm details and data structures.
C/C++ Source code
1. **Background and Motivation**

Driven by the ever-increasing user connection demands, emerging and next generation wireless systems require a high capacity physical layer capable of achieving multiple gigabits capability for single user as well as system capacity of over 100 Gbps. It is anticipated this high capacity and the per user data rates can be partially achieved using full duplex systems. Recent trials show that simultaneous transmission and reception at the base station could be done with up to 110 dB isolation which makes it promising to use full duplex systems for the next generation systems.

However, poor spectrum efficiency of the systems in dense deployment scenario remains an unsolved issue mainly due to different types of interferences that can happen when simultaneous transmissions occur in both UL and DL. For example, in the same base station, an UL transmission from a UE can Impact the DL transmission (UL_UE-DL-UE interference).

Similarly DL transmission can also be interfered by a neighbors cell close UE transmission on the uplink. In addition, the UL transmission can be impacted by the neighbor cell BS DL transmissions (BS to BS). In addition, UL transmit power schemes need to consider the new base station self interference when deciding the transmit power.

This project is dedicated to support innovations in developing practical, high efficient full duplex systems for Indoor and outdoor cellular and relay systems. Topics of interest include, but are not limited to, the following scope.

2. **Scope**

Research scope:
Research and design schemes to improve the performance of full duplex cellular systems under different deployment environments and scenarios and compare the results with half-duplex systems. Some of the performance indices, deployment environments and deployment scenarios are described below.

The performance indices include but not limited to:
- system capacity under different fairness levels,
- quality of user experience and
- end-to-end delay.

The deployment environments include but not limited to:
- all access nodes are indoor pico cells
- All access nodes are outdoor macro cells
- Outdoor hetnet scenario
- Outdoor and indoor deployment with strategic isolation purposes

The deployment scenarios include but not limited to:
- Wireless network where all the access points are full duplex and all UEs are half duplex
- Wireless network but the half duplex and full duplex access points co-exist
and all UEs are half duplex

- Wireless network where all the access points are full duplex and all UEs are full duplex
- Wireless network but the half duplex and full duplex access points co-exist and also there are UEs both half and full duplex

Contents include but not limited to:

- Both analytical performance evaluations and simulation based results under a full system level simulator assuming Métis and/or 3GPP assumptions of system modeling.
- Algorithms for improvement such as power control algorithms, scheduling algorithms, access cell coordination algorithms, partial frequency reuse schemes and hybrid full duplex and half duplex solutions, Hetnet specific solutions
- Cell to cell and UE to UE interference cancellation, mitigation, avoidance schemes and algorithms to improve full-duplex system capacity; Interference measurement and assessment methodologies to assist scheduling in full-duplex networks.

3. **Expected Deliverables**

- Patents
- Papers
- Survey and Research reports

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1. **Background and Motivation**

IEEE 802.11ad specified in 2013 is a Wi-Fi technique operating at the 60GHz unlicensed band (57-66 GHz), which is allocated and harmonized worldwide.

IEEE 802.11ay is an extension of IEEE 802.11ad with a significant increase in the peak data rate (measured at the MAC data service access point) and other updated features. The IEEE 802.11ay Task Group started standardization work in May 2015 and plans to create Draft 1.0 by May 2017.

IEEE 802.11ay is expected to standardize several essential features beyond IEEE 802.11ad such as channel bonding, single user multiple-input multiple-output (SU MIMO) and multiuser MIMO (MU-MIMO) to improve the IEEE 802.11 user experience by significantly increasing throughputs for current IEEE 802.11 applications and to extend/optimize IEEE 802.11ad to enable new applications and market segments.

IEEE 802.11ay standardization can also influence the research and standardization for future 5G/mmWave mobile communications.
2. Scope

Research on SU MIMO and MU MIMO for millimeter wave technology IEEE 802.11ay standardization with potential focuses on
- MIMO techniques for millimeter communications (such as Hybrid beamforming and other techniques)
- Close-loop and open-loop
- Feedback and signaling

3. Expected Deliverables

✓ Two patent applications and related proposals to the IEEE 802.11ay standard meetings.

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1. Background and Motivation

The Beam-forming (BF) information is represented in a series of Givens Rotations, and their corresponding angles are quantized and feedback to the transmitter. The BF information is supposed to be feedback to the transmitter every sub-carrier, though the tone grouping may reduce the total feedback size.

IEEE 802.11ax, which is the latest standards under development in IEEE 802.11, aims at enhancing IEEE 802.11 PHY and MAC in 2.4 GHz and 5 GHz with a focus on improving spectrum efficiency, area throughput, and real world performance in indoor and outdoor deployments. In IEEE 802.11ax, the overhead due to beam-forming feedback is a serious issue mainly because of the following two reasons:

1. IEEE 802.11ax introduces 4 times longer OFDM symbol, that is, 4 times larger number of sub-carriers per symbol, which creates 4 times larger feedback overhead
2. IEEE 802.11ax allows high multiple-input multiple-output (MIMO) configuration (such as 4 or 8 transmit antennas and 2 receive antennas), which results in an exponential increase in the number of angles required to be fed back with the MIMO size. Further, the angles of high MIMO configuration have various probability distribution functions. Most of them are Gaussian distributed, which cannot be quantized well with the current IEEE 802.11 linear quantization.

The objective of this project is to design more efficient beam-forming feedback design for IEEE 802.11ax with high MIMO configuration. Specially, the focus is on
the design of new quantization methods that not only improve the linear quantization schemes that are standardized in IEEE 802.11ac but also further reduce the beam-forming feedback overhead.

2. Scope

- Overall theoretical analysis of source coding and the research of appropriate quantization method
- The research on the reduction of beam-forming feedback overhead
- Provide the theoretical design principle for the proposed quantization method
- Provide the theoretical reason for the performance gain and the overhead reduction

3. Expected Deliverables

- Two patent applications
- Two conference papers and one IEEE level journal submission

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1. Background and Motivation

With the forecasts from Gartner, Inc., that 4.9 billion connected things will be in use in 2015 and 25 billion by 2020, the Internet of Things has become a powerful force for business transformation and it is getting more attention than ever across all industries.

Nowadays, there are many different proprietary technical solutions that are used for connecting devices, or “things” in terms of IoT perspective, to each other and/or to the cloud. The choice of technology is generally dictated by not only physical characteristics of the environment (such as device deployment), but also users’ requirements (such power consumption, throughput, transmission reach). Among these technologies, Wi-Fi has its potential to be the most suitable choice for the IoT because of its proven track record as a ubiquitous standard of connectivity in many market segments (e.g., consumer electronics, enterprise).

The objective of this project is to develop medium access technologies for Wi-Fi based IoT applications that achieve the requirements for power consumption, throughput, transmission reach, integration with the latest IEEE 802.11ax technology, and coexistence with other IEEE 802 wireless protocols operating in the same frequency band.

2. Scope
Technical solutions that are suitable to be applied in Wi-Fi based IoT applications (mainly low power and long transmission reach)
- Technical solutions that can integrate with the latest IEEE 802.11ax technology

3. Expected Deliverables
- Two patent applications
- Two conference papers

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1. Background and Motivation

With the forecasts from Gartner, Inc., that 4.9 billion connected things will be in use in 2015 and 25 billion by 2020, the Internet of Things has become a powerful force for business transformation and it is getting more attention than ever across all industries.

Nowadays, there are many different proprietary technical solutions that are used for connecting devices, or “things” in terms of IoT perspective, to each other and/or to the cloud. The choice of technology is generally dictated by not only physical characteristics of the environment (such as device deployment), but also users’ requirements (such power consumption, throughput, transmission reach). Among these technologies, Wi-Fi has its potential to be the most suitable choice for the IoT because of its proven track record as a ubiquitous standard of connectivity in many market segments (e.g., consumer electronics, enterprise).

The objective of this project is to develop physical-layer technologies for Wi-Fi based IoT applications that achieve the requirements for power consumption, throughput, transmission reach and integration with the latest IEEE 802.11ax technology.

2. Scope

- Technical solutions that are suitable to be applied in Wi-Fi based IoT applications (mainly low power and long transmission reach)
- Technical solutions that can integrate with the latest IEEE 802.11ax technology

3. Expected Deliverables

- Two patent applications
- Two conference papers
1. **Background and Motivation:**

For the past two decades, PtP Micro/mm-wave links have been the primary medium for cellular backhaul. During that period these links advanced from QAM16 with simple Reed-Solomon to QAM8192 with advanced LDPC codes, and spectral efficiency was improved from below 3bit/sec/Hz to over 12 bit/sec/Hz. However the basic concept of QAM modulated, single carrier with RRC shaping was left unchallenged by the advancements of the past twenty years. With the introduction of 5G networks, the required throughput is threatening to render microwave backhaul obsolete unless a more efficient way to use the available spectrum can be found.

2. **Scope:**

We are looking for a modulation scheme, coding scheme or a combination of both that will outperform the combination of QAM LDPC and RRC in the quest to increase the throughput of our link, given limited SNR, limited peak transmit power and limited bandwidth.

3. **Expected Deliverables:**

A mathematical description of the modulation/coding alongside a simulation that proves its superiority over our state of the art QAM/RRC/LDPC.

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1. **Background and Motivation:**

One of the major challenges for the deployment of next generation urban cellular networks was identified as the wireless backhaul of small cell networks. Mm-wave spectrum seems to be a promising wireless alternative to fiber optics. While the urban propagation of mm-wave cellular access was thoroughly investigated, Mm-wave backhaul was not. An industry special interest group is now in the process of drafting the guidelines for backhaul spectrum allocation within V-band, W-band and D-band.
2. **Scope:**

We would like to study the feasibility of mm-wave small cell backhaul networks in various urban environments, with installations above and below the clutter level. Transceivers are collocated with the small cells (and/or the fiber PoP) and are equipped with high gain beam steering antennas.

3. **Expected Deliverables:**

Accurate simulations of several different models.
- Supporting analysis that could guide ETSI mWT SIG for the allocation of frequencies
- Simulation outputs that could drive the decision on the specification of future backhaul products

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1. **Background and Motivation**

As optical network evolves to support data rate 400G and 1T, super-channel is an un-avoidable technology for realizing this high data rate. Architect that utilizes multiple lasers to achieve this will be expensive and impossible to gain performance. Multi-wavelength light source from single laser is desired to reduce cost and to gain performance from cross-channel coding and inter-channel interference cancellation.

2. **Scope**

1) Multi-wavelength light generation from single laser
2) Carrier frequency stability between wavelengths
3) Performance gain obtained from cross-channel coding

3. **Expected Deliverables**

1) Prototype of multi-wavelength light generation from single laser
2) Demonstrated carrier frequency stability between wavelengths
3) Offline DSP and performance simulation and platform
1. Background and Motivation

Current SDN control advocates centralized control for traffic-engineered networks to achieve better control and performance, while there are still networks using protocol-based distributed control such as GMPLS/ASON. It is important to understand under which conditions or in which functional area in traffic-engineered networks is centralized network or distributed control more beneficial with proper analysis. Traffic-engineered networks may include those built of MPLS, MPLS-TP, OTN or WDM optical transport technologies.

2. Scope

To perform analysis studies on the benefit and use case or centralized and distributed control for traffic-engineered networks.

3. Expected Deliverables

Analysis results with specific network scenarios or configurations; simulations; interfaces and protocol pseudo-definitions to support the claimed scenarios.
3. Expected Deliverables

Analysis results with specific network scenarios or configurations; simulations; interfaces and protocol pseudo-definitions to support the claimed scenarios.

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1. Background and Motivation

The user experience of multi-user conferencing may be enhanced by the use of 3-D audio rendering of the participants. Locating each user in 3-dimensional (3-D) space should permit more spontaneous conversations and discussions, whilst permitting the different speakers to be resolved and differentiated. This 3-D rendering requires that the mono source signal be convolved with a pair of Head Related Transfer Functions (HRTFs), where the HRTFs together model the amplitude and phase relationships between the signals reaching the two ears due to the 3-D location of the source signal and the response of the pinnae (outer ears). The convolutions may be performed at a handset, which is provided with all of the multiple mono audio streams, or within a network-based multi-point conferencing unit where each handset is provided with a single stereo coded downlink, but to inform this architectural decision, the answers to several questions would be very useful.

1. Is it possible to determine a generic set of HRTF pairs that are good enough to resolve the front/back up/down confusion that is inherent in 3-D audio rendering across gender, languages and cultures? If a single set is not possible, roughly how many sets would be required and how would selection for each individual be achieved centrally?

2. Given a 3-D audio rendered stereo signal, what coding (downmix) method and bit rate is best adapted to transporting the stereo signal to a user terminal without loss or corruption of the 3-D imaging? How does this relate to the bit rate needed for the individual mono signals?

3. How do human users perceive movement of audio sources and is it possible to users to keep track of the location of single audio sources/callers? How is it best to introduce new speakers into a call, and remove redundant callers, without compromising the 3D spatial differentiation whilst permitting the listeners to keep track of the location of participants?

This project proposal aims to progress knowledge in the area and provide insight and solutions in one of the key unknown areas.

2. Scope

Please choose one topic from the list:

1) Given a number of mono audio signals from different sources, develop algorithms to distribute them spatially and as new signals arrive (and depart) redistribute them as necessary in a smooth, coherent and natural fashion. Evaluate how listeners react to and can track these smooth movements and when/how they should occur.

2) Develop a minimum set of "good-enough" HRTF's for binaural rendering of
speech signals that work across gender, languages and cultures, identifying their shortcomings and limitations.

3) Given a binaural audio signal comprising speech and possibly low level background noise, investigate the impact of different stereo down mix and coding methods (probably need to be standard algorithms) on the perceived audio localization of speech and noise with a view to identifying key features of the binaural signals to be preserved.

3. Expected Deliverables
Source code, simulation testing report and technical report

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1. Background and Motivation

Data for the proliferation of IoT devices is expected to flow into the cloud and to be subject to big data analysis. Some of this IoT data will be personal data of users, or data associated with specific users. Users are rightly concerned that they have control of where this data will flow, and governments and consortium are setting up frameworks for the protection of such data (for example the OTA framework: https://otalliance.org/system/files/files/initiative/documents/iot_trust_framework_11-23.pdf). Cryptographic technologies which can provide control and audit functionality for data flow in the cloud are potentially valuable technologies to assure the users of IoT technology.

Another concern of IoT data collection is the proprietary nature of many of the IoT data services (e.g. Google NEST, Apple Homekit, and many others). In proprietary schemes a real “internet” of the things in question is not created. There seems to be a need for open IoT cloud services, but providing security and privacy.

Once user IoT data has been transferred to the cloud, there is the vulnerability that occurs when the data is used for computation. Fully homomorphic encryption schemes hold the promise of these computations occurring only on encrypted data, but such schemes can be very computationally inefficient. It is of interest to find perhaps somewhat-homomorphic schemes that are very practical but still provide a measure of security.

In another development, efficient secure multi-party computation holds that promise that user secrets (perhaps keys) can be split in the cloud and computation performed on them without the vulnerability of putting all these secrets back together in one location. Which schemes can be made practical and what applications can be serviced by this technology?

2. Scope
Possible research topics include:

- Cryptographic schemes for secure data flow management and auditing in the cloud
- Open secure IoT data architectures for the cloud, where cryptographic techniques are employed to enforce access control and auditing of data usage, but where the existence of such controls allows one architecture and infrastructure to be deployed. Can we build a secure data-plane for IoT as opposed to multiple proprietary solutions?
- Can (somewhat) homomorphic encryption techniques be made practical for IoT data analysis?
- Can secure multi-party computations be used to secure aspects of IoT devices and IoT cloud services? How practical are the derived schemes?

3. Expected Deliverables

- Proof of concept system, preferably using commercial cloud systems and off-the-shelf IoT devices, alongside innovative cryptography and system architectures.
- One or more patents

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<table>
<thead>
<tr>
<th>Subject</th>
<th>Credit Risk Analysis with Big Data</th>
</tr>
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<tbody>
<tr>
<td>Subject No</td>
<td>HIRPO2016CA18</td>
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<tr>
<td>Theme</td>
<td>Big Data</td>
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1. Background and Motivation

Credit risk is an important and widely studied topic in the bank industry for lending decisions and profitability. Credit scoring has become one of the main analytical ways for financial institutions to assess credit risk. Traditionally, the score is calculated using statistical models (i.e., logistic regression), nonparametric statistical models (i.e., k-nearest neighbor), classification trees or neural networks.

With the fast growth of big data and internet, internet companies have started to step into the financial industry. For example, Sesame score from Alibaba collects customer basic information; real-time transaction data from Alibaba’s shopping websites as well as banks and other companies. Sesame score ranges from 350 to 950. The higher the score, the more trustworthy a person is. Zest Finance targets Americans who do not have enough credit history and are unable to apply for loan from traditional banks. Zest Finance collects multi-dimensional datasets and then transforms the raw data to over 70,000 features. These features are then fed into over a dozen machine learning models to generate a credit score. These multi-dimensional models outperform traditional models for over 40% and provide better controls of the financial credit risks.

The success of these internet companies suggests that traditional methods are not sufficient to adapt the big data in the financial credit risk area. To leverage the potential of big data, new methods and tools need to be explored.

2. Scope

Possible research topics include:

- How to use big data technology to process and analyze the valuable information of structured data and unstructured data effectively. A person’s social standing, online reputation and/or professional connections are factors that should be
considered when extending credits, especially to someone who do not have enough credit history and are unable to apply loans from traditional banks. Many internet credit companies are started to collect social media data to assess consumer’s credit risk, such as Lenddo, Neo Finance and Affirm. There are many active research areas in this domain, including:

- Human identity validation.
- Missing data prediction. Big data does not necessarily lead to more information due to the inconsistent data and/or missing values.
- Social credit score prediction. These social credit score can help to answer questions like “Who has better credit? One with 50 FB friends or one with 500 FB friends?”
- Credit prediction. How to combine the structured data and unstructured data to assess the credits
- Future delinquencies prediction

- Data visualization. Machine learning is powerful but it is challenging to make the results interpretable for the human.
  - Rule extraction. How to extract the rules from the credit score predictive models?
  - Intelligent, interactive data visualization

3. Expected Deliverables
   - New algorithm or system
   - Demo system for an intelligent, interactive data interface
   - One or more patents

<table>
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<tr>
<th>Subject</th>
<th>Intelligent, Interactive Interfaces for Machine-Generated Big Data</th>
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<tbody>
<tr>
<td>Subject No</td>
<td>HIRPO2016CA19</td>
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<tr>
<td>Theme</td>
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1. Background and Motivation
   Much of the growth in modern ‘big data’ is due to machine-generated data, such as application logs, web server logs, sensor data, and records of financial transactions. Big data processing platforms such as Hadoop have enabled organizations to unlock value in their massive machine data collections. Organizations are using these platforms to run scalable analyses on their data, gaining insight into the health of their systems and the activities of their customers.

   At the same time, as big data platforms have matured, the job of analyzing big data is expanding from an initial group of deep programmers writing batch jobs (e.g. in the MapReduce paradigm) to data scientists and business intelligence professionals able to query data interactively using SQL, Python, R, etc. As this trend continues, big data analysis will become more and more accessible to non-technical people.

   However, making intelligent, interactive interfaces for machine data is especially challenging; beyond its sheer volume and velocity, machine data also arrives in a variety of formats, and is often unstructured in nature. Nevertheless, users will ultimately expect a machine data analytics platform that is as simple to interact with
as talking to an expert - or at least as simple as searching on Google.

2. **Scope**  
Possible research topics include:
- Natural-language interfaces to big machine data, including:
  - Support for temporal queries, e.g. “Show me sales over the last 6 months, weekdays from 9am to 930am, & 3 to 4pm, except every second Thursday.”
  - Automatic compilation of user queries into regular expressions, e.g.: “Messages with the word ‘error’ followed by words with sequences of 3 digits”, “messages with all letters capitalized”
  - Understanding and plotting of quantification, correlations, etc. in user queries, e.g. “Show me CPU usage versus memory for all machines in data center #2”
  - Assistance to users: spelling correction, autocomplete, automatic query refinements/suggestions
  - Multi-lingual interfaces
- Information extraction on machine data, to support intelligent interaction:
  - Automatic field extraction in data
  - Recognition of time expressions in data
  - Automatic schema construction
- Approaches for enabling effective machine data interaction on small personal devices
- Spoken language interfaces to machine data
- Intelligent, interactive visualizations for machine data

3. **Expected Deliverables**
- Demo system of an intelligent, interactive machine data interface
- One or more patents

<table>
<thead>
<tr>
<th>Subject</th>
<th>Human Activity Analysis and Recognition</th>
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<tbody>
<tr>
<td>Subject No</td>
<td>HIRPO2016CA20</td>
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<td>Theme</td>
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1. **Background and Motivation**  
In recent years, there has been an ever-increasing interest in video surveillance within government bodies, industrial companies and academic research labs. The cost of deploying surveillance camera network within a small area such as an office building or a large geographical region across multiple cities and province has been significantly reduced thanks to the technological advance in HD video camera, high speed network and streaming, and large scale storage. The key strength of a video surveillance system lies in the capability of analyzing the semantic content of large video datasets to acquire the insight for making informed business decisions.

2. **Scope**  
The Canada Research Centre of Huawei Technologies has launched a big video
analytics project. From the perspective of practical applications, we focus on the scenarios related to public security and health care. In terms of the key technology development, our goal is to use computer vision and machine learning technologies to solve the analysis and recognition of human activities through both offline data processing and online stream predictive analytics.

Following are some examples of human activities that are under consideration in our video analytics project.

1) Emergency detection in a hospital
   A video surveillance system deployed in all the buildings of a hospital is desired to be capable of recognizing an event described as follows. A person (patient, visitor, or employee) falls down on the ground. He/she cannot move any more, or he/she has difficulty getting up again. Not long after or immediately, there are people gathering around trying to offer help. This event is highly possible to be an emergency event that the hospital should respond to.

2) Child endangerment
   Child endangerment involves a wide array of criminal behaviors. In the context of our project, we intend to recognize the activity of stealing children two years old or younger left by their parents unattended in an environment such as a crowded shopping center or airport.

3) Organized group of thieves
   In this scenario, we are interested in recognizing the activity of stealing high value personal assets, e.g. automobiles, conducted by a group of thieves. The crime scene of this scenario is usually underground parking lot.

4) Affray detection
   Affray can evolve into serious life-threatening criminal behavior without timely control by the police or security personnel. Our need is to recognize this type of behavior which occurs in any kind of public environment.

3. Expected Deliverables
   - Demo system
   - One or more patents

<table>
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<tr>
<th>Subject</th>
<th>Person Re-identification for multi-camera video surveillance</th>
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<tr>
<td>Subject No</td>
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1. Background and Motivation

Person re-identification is defined as the problem of associating an identifier with all the visual instances of a particular person in a video dataset, recorded by a system with multiple cameras.

The challenges:

- There may be a significant gap in the time and spatial domains between the visual instances of a person recorded by different cameras, which violates the
constraints on both spatial-temporal continuity and visual appearance constancy. Traditional appearance-based techniques are not sufficient to handle the large degree of photometric and geometric variation in this scenario.

- The recorded videos are subject to various types of noise, distortion. Due to the long distance between human subjects and cameras, the effective number of pixels of each human body region is very low. Therefore, conventional biometric information is not reliable in this scenario.
- Because the target application for us is video surveillance, the human subjects of interest to the users of the technology may be uncooperative, resulting in an even lower level of discriminability between the visual instances of different people.

2. Scope

Our goal is to develop some technology for person re-identification where there is a significant gap in both time and spatial domains, as well as low-resolution for human body regions. Due to the difficulty of using visual appearance alone in this case, we plan to exploit soft-biometrics, such as gender, height, age, and ethnicity and 2D and 3D body models to help improving visual appearance-based person re-identification.

3. Expected Deliverables
- Demo system
- One or more patents

<table>
<thead>
<tr>
<th>Subject</th>
<th>A processing-in-memory framework to solve graph and other big-data problems</th>
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<tr>
<td>Subject No</td>
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<td>Theme</td>
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1. Background and Motivation

Processing-in-memory (PIM), which was also known as processor-in-memory, is a long-live technique which dates back to 1990s. However, none of the PIM prototypes in that time has breached the industry. The key problem is due to the problem on integrity between the computation logic and the highly-integrated memory cells. Very recently, this technique has been revived, since the above integrity problem was partially solved by the 3D stacking. Several new memory models, with computation logic, stacked with layers of memory layers, have shown their potential in future computations.

However, several issues, including the programmability, and the coherence with normal memory space processing, still remain challenging for the final success of PIM. Suffering from an immature programmability, PIM accelerators can hardly compete with commonly-used GPU accelerators, though GPU also originally suffered in the software part at the very beginning. Also, due to Amdahl's law, the acceleration, from PIM should be of sufficiently large portion to benefit the total computation procedure, since most PIM operations currently still remain primitive...
due to the logic complexity.

One good chance for PIM is to handle big-data applications which are more data-centric than the computation centric. For this purpose, PIM needs to handle the somehow irregular data organization and patterns in most big-data applications. It is expected the proposal can give some break-through in the PIM architecture design, the programmability of the PIM, and the framework to transfer big-data application in a PIM-enabled system, with the awareness of the special data organization of the very big-data application.

2. Scope
- A practical architecture design of PIM, with the fully consideration of hardware complexity, memory bandwidth and etc.
- A programmable framework for the PIM
- Considerations of keeping atomic operation between PIM and CPU cache hierarchy
- Considerations of coherence between PIM (physically addressed) and virtually addressed space
- Translation several big-data applications to the PIM-enabled framework

3. Expected Deliverables
- A patent application
- A paper
- A prototype validating the proposed algorithm

<table>
<thead>
<tr>
<th>Subject</th>
<th>Unsupervised learning for understanding temporal sequences</th>
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1. Background and Motivation

Sequence learning is a fundamental problem which is vitally important for solving many AI tasks such as speech recognition, visual understanding, action recognition, Q&A, and so on. Supervised sequence learning has made significant progress in past several years. A commonly used framework is to use recurrent neural networks to encode the input information to a fixed length representation, which has achieved state-of-the-art performance on several benchmark problems. However, most existing approaches require a large amount of labeled data to train the neural network model. It is extremely expensive to obtain labels for big data problems. It is necessary and rewarding to extend the supervised sequence learning to an unsupervised setting.

Unsupervised learning aims to discover regularities and latent structures in unlabeled data. A variety of challenges remain in unsupervised learning. For example, many algorithms are based on predictions of certain distributions, but it is computationally intractable to deal with continuous or compositional data. Noises
are inevitable in many practical applications, but many existing algorithms would fail in the presence of noise, especially in a high dimensionally space. Choosing the right objective function is crucial to extract useful features, but a design methodology is still missing. As such, many issues deserve further in-depth investigations.

The objective of this project is to develop high performance algorithms for unsupervised sequence learning. It is expected that the proposed method can achieve state-of-the-art performance on certain applications such as image/video recognition or natural language processing.

2. **Scope**
   - Models and learning algorithms of unsupervised sequence learning.
   - End-to-end technical solutions to an AI application which can be, but not limited to, action recognition in images/videos, natural language processing, or Q&A systems.

3. **Expected Deliverables**
   - A survey report of existing approaches to sequence learning with deep analysis on their strength, weakness, and applicability.
   - Two conference papers
   - An end-to-end demo