Deep Analytics:

Technologies for Humanity, AI & Security

1st Edition, 2021

By

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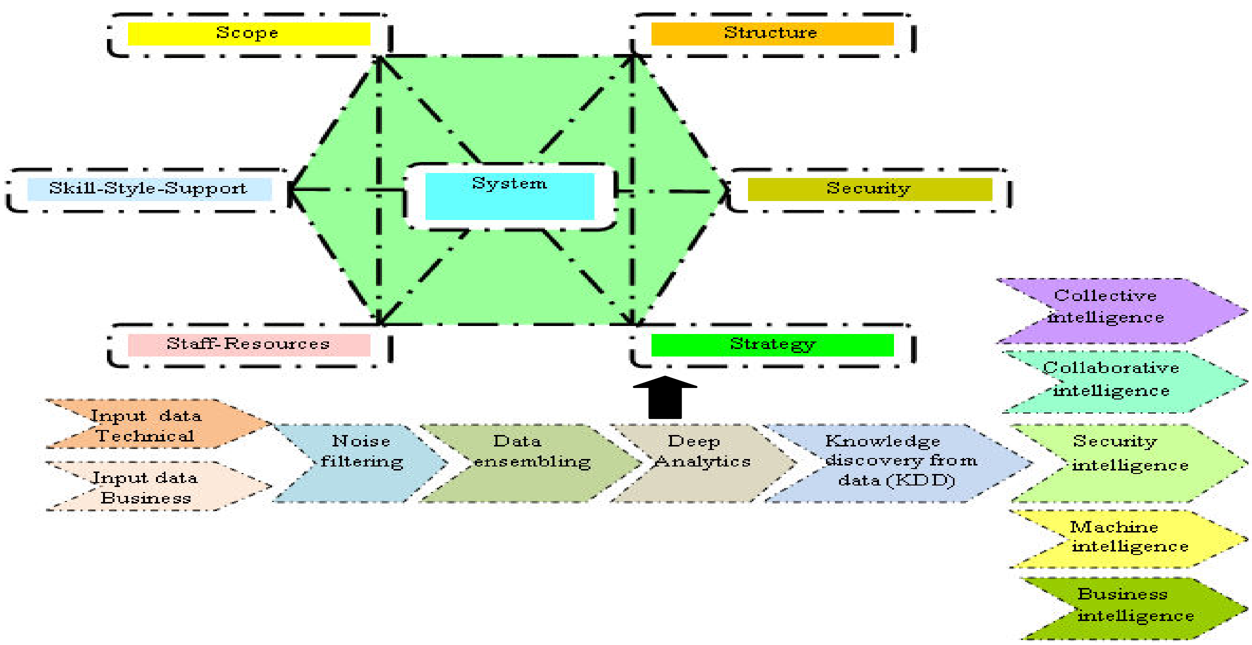

Natural disaster security : Artificial rainfall, Bushfire

Food & home security: smart agriculture, nanohousing

Education security : Learning policy, methodologies

Health security : cancer, biomedical technology, epidemic

Energy & utilities security: Solar power

Logistics Security: Electrical vehicles, DAS, RTFD

Financial security: Fault attacks, Sybil attack

Social security: social networking, digital governance, HRS

Digital technologies security : E-Governance

Preface

Deep analytics does not only mean statistics or data mining or big data analytics, it is a complex multi-dimensional analysis through '7-S' model based on rational, logical and analytical reasoning from different perspectives such as scope, system, structure, security, strategy staff-resources and skill-style-support. This book presents an analytical model through a consistent and systematic approach and highlights its utility and application for reasoning the complexity of a set of emerging technology innovations today: (a) Technology for humanity, (b) Deep analytics - '7-S' model, (c) Solar computing and self-healing mechanism, (d) Adaptive security for SCADA & Industrial Control System, (e) Secure Multi-party Quantum Computing, (f) Secure adaptive filter in adversarial environment, (g) Solar power electronics & Nanotechnology, (h) Electrical and hybrid vehicles : smart batteries, (i) RailTech security: Driver advice system & real-time fault diagnistics, (j) Cancer prediction and prevention: deep learning, (k) Biomedical technology for cancer care, (l) Natural disaster : epidemic and pandemic outbreak control, (m) Artificial rainfall, laser and cloud physics, (n) Real-time moving target search for astronomical hazards, (o) smart agriculture and nanhousing technology for smart cities and smart villages and (p) Emerging digital technologes for social, financial and education security. All the characters, sessions, plot and storyline of the technologies for humanity summit mentioned in this book are imaginative. Kusumita Chakraborty has contributed on education and social security and Suryashis Chakraborty has contributed on social and financial security.

The reality is that every stakeholder is impacted by the challenges and opportunities of innovation ecosystems today. The concept of technology for humanity and deep analytics is still relatively new; it has now emerged as a powerful tool for business analytics and a real world theme in the modern global economy. The target audience of this book includes academic and research community, corporate leaders, policy makers, administrators and governments, entrepreneurs, investors, engineers, producers and directors interested in production of documentary films, news and TV serials. We are excited to share the ideas of deep analytics with you. We hope that you will find them really value adding and useful and will share with your communities. It is a rational and interesting option to teach deep analytics in various academic programmes of various Business Management programmes (e.g. Technology Management, Human Resources Management, Information Technology, Information Systems, Management Information Systems (MIS), Strategic Management and Analytics for BBA, MBA, PGDM, PGDBM) and also Electrical and Electronics Engineering (e.g. B.Tech, M.Tech, B.E.E., M.E., Ph.D.). It is also interesting to produce TV serials, webseries and moviesand organize global summit on technologies for humanities based on the plot of this book. This e-book is the electronic version of 1st edition; Price: ($250 per copy). This book contains information obtained from authentic sources; sincere efforts have been made to publish reliable data and information. Thanks and regards.

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Business Analytics Research Lab, India. 1.1.2021

Content

SESSION 1: DEEP ANALYTICS - TECHNOLOGIES for HUMANITY and GLOBAL SECURITY

Event **: Technology for humanity and global security summit**
Venue**: Deep analytics hall, Technology park : Sanada**
Time Schedule **: 9 a..m. – 1 p.m. , 15.8.2020**
Agents **: Representatives of various global organizations (nations, childcare, peace, health, bank, economic forum), Technology management experts from science and technology forums, scientists, representatives and ministers from the departments of science and technologies of developed, developing and underdeveloped countries, CEOs of global corporations, business development consultants, representatives from NGOs.**
Key focus areas **: Deep analytics, 7-S model, Technologies for humanity, Global security, Sustainable development goals, Economic growth, Poverty, Jobs, Environmental protection, Business model innovation, Global welfare.**
Keynote speakers**: Prof. Nil Bajjio, Prof. Michel Johnson, Prof. Kalyan Som, Prof. David Milla, Dr. Rojer Moore, Dr, M. Schilling, Dr. S.Chakraborty.**

1. DEEP ANALYTICS

It is a sunny, windy morning. Seven hundred participants from all over the world have come to the technology park, Sanada to attend Technology for humanity and global security summit'2020. The President of Sanada has inaugurated the summit. It is an open forum; there are ten interactive brainstorming sessions; the participants are raising a set of debtable and intelligent questions on poverty, sustainable development goals, global security policy, business model innovation, economic growth and entrepreneurship. Dr. S.Chakraborty is presenting the basic overview of deep analytics. He is outlining the concept and mechanism of deep analytics to evaluate technology management in terms of seven 'S' elements (scope, system, structure, security, strategy, staff-resources and skill-style-support). He is also defining the significance of various parameters in the context of technology management such as technology security, technology classification, technology association, technology clustering, technology prediction or forecasting, innovation, adoption, diffusion, infusion and dominant design. The other objective of this session is to analyze the emerging concept of technology for humanity and select a set of emerging technologies for the sustainability of human civilization.

Deep analytics is an intelligent, complex, hybrid, multi-phased and multi-dimensional data analysis system [Figure 1.1]. The basic steps of computation are data sourcing, data filtering / preprocessing, data ensembling, data analysis and knowledge discovery from data. The authorized data analysts select an optimal set of input variables, features and dimensions (e.g. scope, system, structure, security, strategy, staff-resources, skill-style-support) correctly being free from malicious attacks (e.g. false data injection, shilling); input data is sourced through authenticated channels accordingly. The sourced data is filtered, preprocessed (e.g. bagging, boosting, cross validation) and ensembled. It is rational to adopt an optimal mix of quantitative (e.g. regression, prediction, sequence, association,

classification and clustering algorithms) and qualitative (e.g. case based reasoning, perception, process mapping, SWOT, CSF and value chain analysis) methods for multi-dimensional analysis. The analysts define intelligent training and testing strategies in terms of selection of correct soft computing tools, network architecture – no. of layers and nodes; training algorithm, learning rate, no. of training rounds, cross validation and stopping criteria. The hidden knowledge is discovered from data in terms of collective, collaborative, machine, security and business intelligence. The analysts audit fairness and correctness of computation and also reliability, consistency, rationality, transparency and accountability of the analytics.

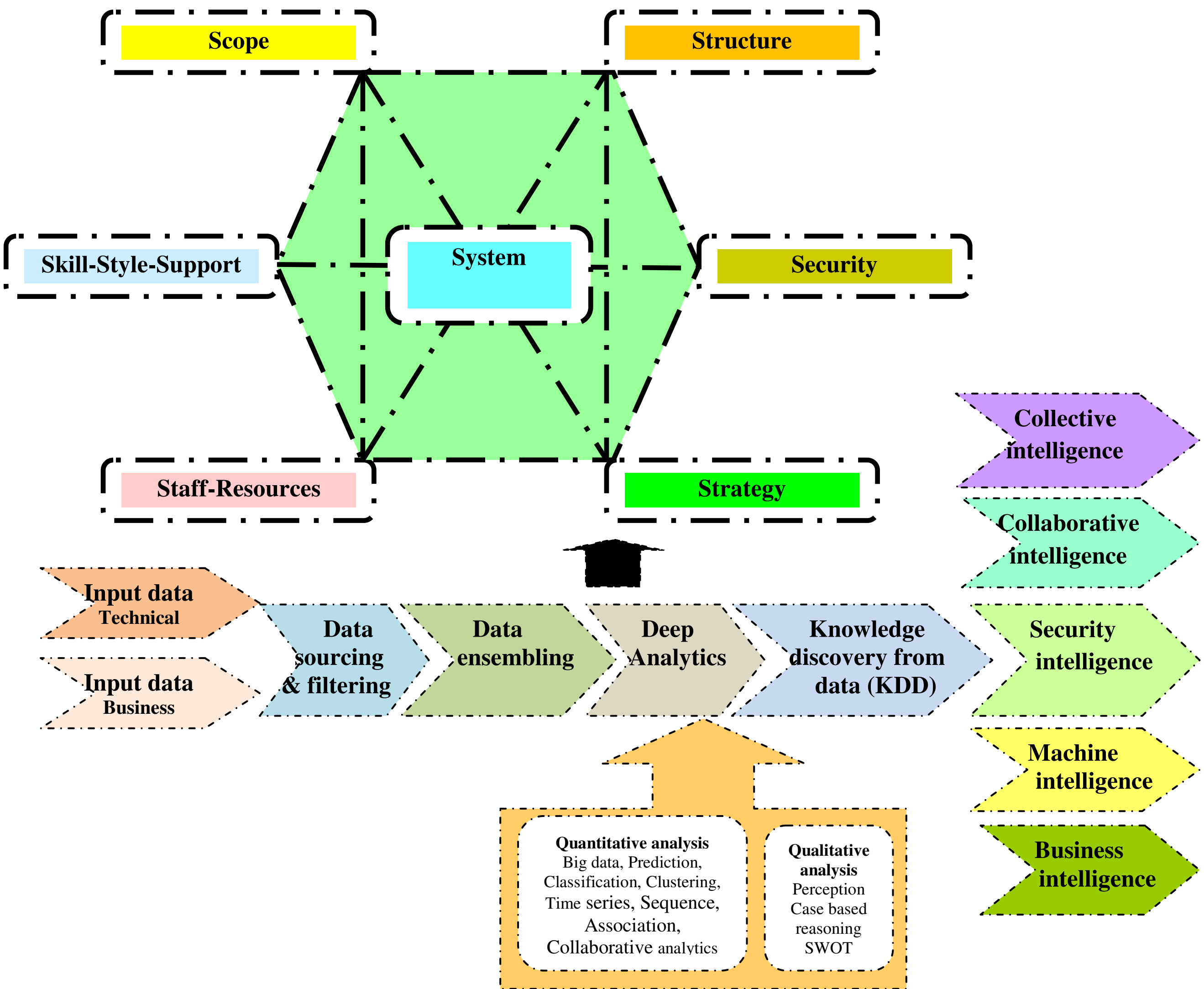

Figure 1.1 : Deep Analytics

Deep analysis can process precisely targeted, complex and fast queries on large (e.g. petabytes and exabytes) data sets of real-time and near real-time systems. For example, deep learning is an advanced machine learning technique where artificial

neural networks (e.g. CNN) can learn effectively from large amount of data like human brain learn from experience by performing a task repeatedly and gradually improves the outcome of learning. Deep analytics follows a systematic, streamlined and structured process that can extract, organize and analyze large amounts of data in a form being acceptable, useful and beneficial for an entity (e.g. individual human agent, organization or BI information system). It is basically a specific type of distributed computing across a number of server or nodes to speed up the analysis process. Generally, shallow analytics use the concept of means, standard deviation, variance, probability, proportions, pie charts, bar charts and tabs to analyze small data set. Deep analytics analyze large data sets based on the concepts of data visualization, descriptive and prescriptive statistics, predictive modeling, machine learning, multilevel modeling, data reduction, multivariate analysis, regression analysis, logistic regression analysis, text analysis and data wrangling. Deep analytics is often coupled with business intelligence applications which perform query based search on large data, analyze, extract information from data sets hosted on a complex and distributed architecture and convert that information into specialized data visualization outcome such as reports, charts and graphs. In this summit, deep analytics has been applied for technology management system (TMS).

Technological innovations are practical implementation of creative novel ideas into new products or services or processes. Innovations may be initiated in many forms from various sources such as firms, academic institutions, research laboratories, government and private enterprises and individual agents. There are different types of innovations from the perspectives of scope, strength, weakness, opportunities, threats and demands from the producers, service providers, users, service consumers and regulators.

Innovation funnel is a critical issue in technology management; innovation process is often perceived like a funnel with many potential ideas passing through the wide end of a funnel but very few become successful, profitable, economically and technically feasible products or services through the development process. Deep analytics is an intelligent method and consulting tool that is essential for effective management of top technological innovations today. It is basically an integrated framework which is a perfect combination or fit of seven dimensions. Many technological innovation projects fail due to the inability of the project managers to recognize the importance of the fit and their tendency to concentrate only on a few of these factors and ignore the others. These seven factors must be integrated, coordinated and synchronized for the diffusion of top technological innovations globally.

Deep Analytics Mechanism [DAM]

***Agents*: Single or a group of data analysts;**

***System* : Technology Management System /* Technology for humanity*/**

***Moves*:**

- **Adopt a hybrid approach : quantitative ⊕ qualitative;**
- **Optional choices :**
    - **Collaborative analytics /* agents : multiple data analysts*/**

- **Big data**
- **Predictive modelling**

***Objectives*: Evaluate an emerging technology for innovation, adoption and diffusion;**
***Constraints*: Availability of authenticated and correct data, time, effort, cost;**
***Input*: Technical data (D_t), Business data (D_b); /* Entity : An emerging technology for humanity*/**
***Procedure*:**

- **Source data (D_t, D_b);**
- **Filter data;**
- **Ensemble data;**
- **Analyze data → select choice**
  - ***Choice 1*: qualitative analysis (Perception, Case based reasoning, SWOT, TLC);**
  - ***Choice 2*: quantitative analysis (Prediction, Simulation);**
  - ***Choice 3* : Hybrid (quantitative ⊕ qualitative);**
- **Multi-dimensional analysis → KDD (S_1, S_2, S_3, S_4, S_5, S_6,S_7); /* S_1: Technology scope, S_2: System, S_3 : Structure, S_4: Technology security, S_5: Strategy, S_6: Staff-resources, S_7: Skill-style-support; KDD: Knowledge discovery from data */**

***Revelation principle*:**

- **Define information disclosure policy → preserve privacy of strategic data.**
- **Verify authentication, authorization and correct identification in data sourcing.**
- **Audit fairness, correctness, reliability, consistency and rationality of analytic computation.**

***Payment function* : Compare a set of technologies based on cost benefit analysis.**
***Output*: Technology intelligence (collective, collaborative, security, machine, business);**

Deep analytics is essential to understand the nature of a technological innovation and identify the gaps between as-is and to-be capabilities in a systematic and compelling way. It reasons seven dimensions under three major categories: (a) *Requirements engineering schema*: scope [S_1]; (b) *Technology schema* : system [S_2], structure [S_3], security [S_4] and (c) *Technology management schema* : strategy [S_5], staff-resources [S_6] and skill-style-support [S_7] [Figure 1.1]. This session analyzes each dimension briefly and reasons a set of cases of top technology innovations today in next sessions [2-10] applying the tool of deep analytics. The basic building blocks of our research methodology include critical reviews of existing works on technology management and case based reasoning. We have reviewed various works on technology management. We have collected the data of the cases from various technical papers and secondary sources. Session 10 concludes this summit.

2. SCOPE

Prof. Nil Bajjio is exploring the scope of deep analytics. Technological innovation is basically associated with new product development and new process innovation, act

and initiatives of launching new devices, methods or materials for commercial and practical applications. It is one of the most critical competitive drivers in many industries such as information and communication technologies, high technology manufacturing and life-science. Deep analytics explores miscellaneous issues of top technological innovations today such as dynamics of innovation, innovation strategy and implementation process; the impact of globalization of markets and advanced information and communication technologies, computer sided design, computer aided manufacturing, flexible manufacturing system, economic feasibility, economies of scale and short production run; technology life cycle, technology diffusion; social, environmental and economic effects, negative effects of technological changes; R&D fund allocation strategy; pace, advantages and disadvantages of innovation, critical success factors, causes of failure; cost optimization and differentiation. Technological innovations are essential to create new business models. But, many innovation projects fail to make profit due to various reasons such as scope creep or ill-defined scope analysis.

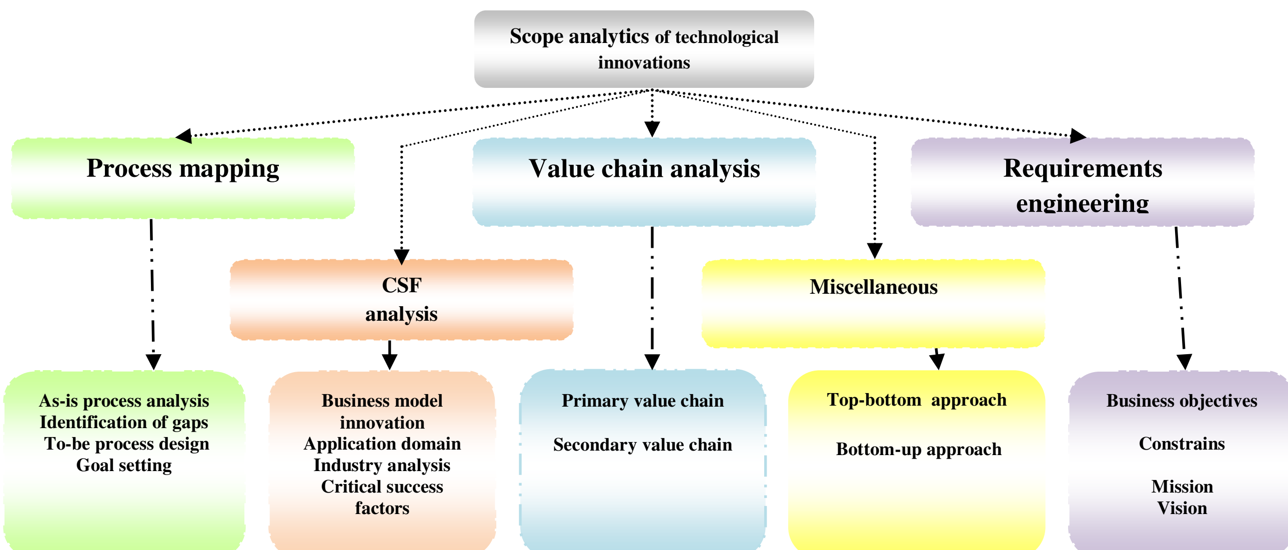

Figure 1.2 : Scope analytics

The first element of deep analytics is *scope*: How to define the goal of an emerging technology? The scope of a technology innovation project should be explored through various scientific and systematic methods such as sustainable goal setting, process mapping, critical success factors *(CSF) analysis*, *value chain analysis*, analysis of business objectives, constraints, requirements engineering, mission, vision and *top-down* and *bottom-up approaches* [Figure 1.2]. Process mapping analyzes a set of critical issues: what is as-is process? How to identify gaps of as-is process? How to innovate to-be process? What are the inputs, outputs, mechanism and constraint for each task associated with a business process? How to configure process flow diagram? The basic objective of CSF analysis is to identify a set of critical success factors through business model innovation, application domain and industry analysis.

The scope of a technology innovation project is explored based on CSFs. The basic objective of *value chain analysis* is to find out a set of critical parameters: what is value; it may be product differentiation, cost leadership or improved quality of services? How to define value in a technology innovation? What are the activities associated with primary and secondary value chain? Primary activities add value to a product and service directly such as manufacturing and supply chain management; secondary value chain activities (e.g. HR, Maintenance) support primary value chain activities. *Top bottom approach* analyzes business plans and goals of a firm, defines the basic needs of a system and explores the scope of technology innovation projects. On the other side, bottom up approach analyze as-is system, identifies gaps and explores the basic needs or scope of a project.

The scope of a technological innovation should be explored through *industry analysis* and also external environment and various stakeholders associated with the value chain. In this connection, *Porter's six force model* is useful to assess the bargaining power of the customers and suppliers, role of compliments, threats of new entrants and substitutes and competition. The internal environment should be accessed through SWOT analysis, identification of core competencies and rigidities, dynamic capabilities, potential strength and opportunities of sustainable competitive advantages. The scope should be also explored in terms of strategic intent, vision, mission and goals from different perspectives such as process innovation, organization learning, financial performance and customer satisfaction.

The scope of technological innovations may be analyzed from the perspectives of product or process innovation, radical or incremental, architectural or component and competence enhancing or destroying innovation. Product innovations occur in the outputs of a firm as new products or services. Process innovations try to improve the efficiency of business or manufacturing process such as increase of yield or decrease of rejection rate. Component or modular innovation changes one or more components of a product. Architectural innovation changes the overall design of a system or the way the components of a system interact with each other. Radical innovation is new and different from prior solutions. Incremental innovation makes a slight change of existing product or process.

We have explored a set of innovative concepts such as technology for humanity, cancer genomics, separating chromosomes, DNA computing, large scale cheap solar electricity and photovoltaics technology, solid state batteries, synthetic cells, next generation predictive, collaborative and pervasive analytics, big data analytics, adaptive security and dynamic data protection, secure adaptive filter, secure multi-party quantum computing, smart transformers, applied AI and machine learning, deep learning, assisted transportation, Internet of Things (IoT), cloud computing and cloud streaming, Internet of bodies, Blockchain and distributed ledger technology, homomorphic encryption, crash-proof code, social indexing, gestural interfaces, social credit algorithms, advanced smart material and devices, activity security protection, virtual reality, chatbots, automated voice spam prevention, serverless computing, edge computing, real-time ray tracing, digital twins, tablets and mobile devices in enterprise management, innovative mobile applications and interfaces for a multichannel future, human computer interface, context aware

computing and social media, enterprise app stores and marketplaces, in-memory computing, extreme low energy servers and strategic global sourcing.

The expert panel are defining technology for humanity and debating on its relevance today from the perspectives of sustainable development goals, global security policy and welfare, economic growth, poverty, new job opportunities, business model innovation, environmental pollution, skill development and talent management. They have selected a set of interesting and emerging technologies for the sustainability of human civilization. Some of these technologies are at emergence or birth phase of technology life-cycle: deep analytics, solar computing, adaptive security, secure adaptive filter and secure multi-party quantum computing. The other technologies are growing at moderate rate. Another objective of this session is to explore the concept of technology security, technology transition, technology classification, technology association, technology clustering, technology prediction and innovation, adoption and diffusion of technologies for humanity globally.

Scope Analytics

***Agents*: System analysts, business analysts, technology management consultants;**

***Objects / entities*: sustainable smart cities, smart villages, communities, smart world, smart universe;**

***Moves* : Critical success factors analysis, Process mapping, Value chain analysis, Requirements management;**

***Global security parameters*: define a set of sustainable development goals.**

- **Poverty control**
  - **Food security (zero hunger)**
  - **Home security (disaster proof nano-housing schema)**
  - **Garments and consumer goods security**
  - **Education security**
  - **Healthcare security (good health, well being, family planning, population control)**
  - **Financial security (banking, financial services, tax, insurance, retirement planning, stock and derivative trading, economic growth)**
  - **Energy security (clean and affordable renewable energy)**
  - **Utilities security (clean water and sanitaion, gas, computing, internet, telecom)**
  - **Communication security (internet, broadcast, satellite communication)**
  - **Logistics security (travel, hospitalities, surface, water, rail, water, EVs and hybrid vehicles)**
  - **Information, media and entertainment security**
- **Social security (HR security, decent work, religious and cultural security, gender equality, child security, women's empowerment, peace, justice, partnership, regulatory compliance, strong institutions)**
- **Natural disaster security (climate change, flood, drought, storm, cyclone, earthquake, volcano, snowfall, rainfall, fire, bushfire, global warming, heat wave, epidemic, astronomical hazards) (attack of wild animals, insects,**

paste); artificial disaster security (defense, war, act of terrorism, bioterrorism)

- **Responsible consumption and production (Enterprise Resource Planning, Supply Chain Management)**
- **Industry, innovation and infrastructure (smart cities, smart villages)**
- **Life on land (environmental pollution, conservation of resources and forest, population control)**
- **Life below water (marine life, water pollution, global warming, oil leakage, nuclear explosion)**

Technology for humanity involves integrated strategic planning, forecasting, design, optimization, operation and control of miscellaneous technological products, processes and services for the sustainability of human civilization and to understand the dynamics of technology innovation, hype, priority, capability, maturity, adoption, diffusion, infusion, transfer, life-cycle, dominant design, spillover effects, blind spots and also the value of emerging technologies for our society. How do we define 'Technology for humanity'? In our society, there is very little discussion about what is needed to fundamentally improve our collective quality of life through fundamental rethinking and radical redesign of systems and processes. How do we evolve our societies into something more productive, more rewarding and more in harmony with our natural environment against various threats of disaster? Emerging technologies can not only improve the world in which we live, they can alter who we are as human beings and can shape and improve our quality of life. The next big tech trend is technology for humanity. It is hard to visualize a roadmap from industry, government, academia & R&D communities of what future jobs and the economy might offer to people and what society might look like. By historic measures, future predictions are mostly incorrect. We need a better balance in our thoughts in terms of fairness, correctness and rationality. There is no reason why man and machine cannot work together, with humans at the controls. There is no reason why we cannot make decent investment returns and create meaningful job opportunities through business model innovation and new technologies build communities and protect the environment from pollution. Technology for humanity is definitely about putting the human society back into technology led globalization.

2020 is the year of coming out of the hype of old, traditional, dead and obsolete technologies. Realistically, it involves the critical role of human innovators in shaping a set of emerging technologies to improve the state of humanity. Technology is an enabler, the human society need to aggressively deploy it to address the critical issues of human society globally. These are basically sustainable development goals. Global goals are a universal call to action to end poverty, protect the planet from natural disasters and environmental pollution and ensure that our society enjoy peace and prosperity through business model innovation and creating new jobs opportunities using our human and technological superpowers and imagination. It is humanity and technology working together to solve various problems, assess and mitigate risks properly. The society have to allocate and share resources (e.g. man , machine, material, method and money) rationally and optimally by trading off risk and return intelligently. The society have to learn how to make acceptable risk adjusted returns eliminating hunger and poverty, creating employment diversity at

decent wages and cleaning up the planet. The society can no longer reward behaviors and outcomes that put humanity, communities and the planet in existential jeopardy. There is no point in arguing about a few % better return on capital when half of the world is underwater.

The expert panel are exploring the scope of technologies for humanity based on global security policy and a set of sustainable development goals. What is goal? There are different types of goals such as process goals (with control), performance goals and outcome goals (with least control). Can we define a rational global security policy? What should be the goals for a rational global security policy? How can we define sustainability: is it possible to meet the needs of the present society without compromising the ability of future generations to meet their own needs? What are Sustainable Development Goals (SDGs) or global goals for the sustainability of human civilization: can we protect our planet, the Earth, even this great universe by ensuring peace and prosperity and ending poverty?

Let us analyze the rationality, fairness and correctness of global security policy? What should be the vision of future world: universal respects for human rights and dignity, the rule of law and justice for equality and non-discrimination, end of hunger and improved nutrition through food security and sustainable agriculture, ensuring healthy life-style and promoting well-being for all at all ages, ensuring inclusive and equitable quality education, promotion of lifelong learning opportunities for all, gender equality and women empowerment. This goal setting demands the commitment, self-determination and trust among all nations to take necessary actions against climate change, unemployment, poverty and environmental pollution. It is crucial to maintain global security, peace, cooperation, collaboration and equality to solve economic, social, cultural and humanitarian problems. The basic objective is to define a set of universal goals that meet the urgent economic, political and environmental challenges facing our world.

Sustainable Development Goals (SDGs) are a collection of global goals to achieve a better and more sustainable future for all within a specific timeline: no poverty, zero hunger, good health and well-being, quality education, gender equality, clean water and sanitation, affordable and clean energy, decent work and economic growth, industry, innovation, and infrastructure, reducing inequality, smart cities, villages and communities, responsible consumption and production, climate action, life below water, life on land, peace, justice, strong institutions and partnerships for goals. The goals are broad based and interdependent. Is it possible to innovate a set of emerging technologies for humanity to achieve sustainable development goals and to track and visualize progress towards the goals through a set of performance indicators?

3. SYSTEM

Prof. Michel Johnson is analyzing the second element of deep analytics - system [Figure 1.3]. A system is a complex grouping of interrelated parts i.e. machines and agents; it can be decomposed into a set of interacting sub-systems. A system may have single or multiple objectives; it is designed to achieve overall objectives in the best possible way. It is possible to analyze a system from the perspectives of system

state, complexity, model, environment, system dynamics, cause effect analysis, feedback loop, physical and information flows and policy decisions. A system may be open or closed loop. A hard system clearly defines objectives, decision making procedures and quantitative measures of performance. It is hard to define the objectives and qualitative measures of performance and make decisions for a soft system. The state of a system at a specific time is a set of relevant properties of the system. The complexity of a system can be analyzed in terms of number of interacting elements, number of linear and nonlinear dynamic relationships among the elements, number of goals or objectives and number of ways the system interacts with its environment. A model is an abstraction of real system. A model is isolated from its environment through model boundaries. A model may be static or dynamic, linear or non-linear based on functional relationship among various variables in a model.

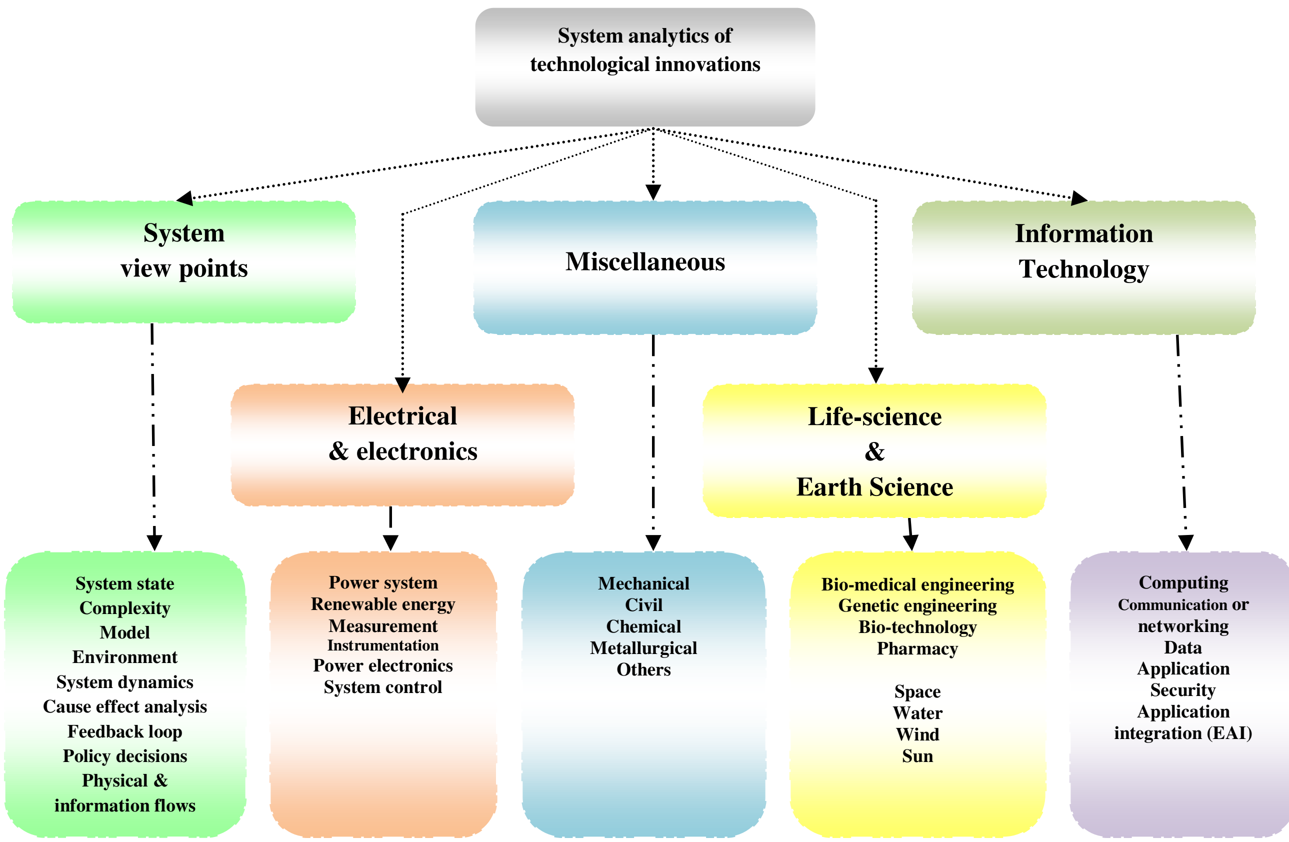

Figure 1.3 : System analytics

A complex system can be analyzed from the perspectives of different branches of engineering and technology such as information and communication technology, electrical and electronics, mechanical, civil, chemical, metallurgical, biotechnology, genetic engineering, pharmacy and others. IT system can be analyzed in terms of computing, communication or networking, data, application and security schema and also application integration (EAI). An electrical system may have various

subsystems such as power system, renewable energy, photonics, system control, power electronics, machines, measurement & instrumentation, illumination and high voltage engineering. A complex system may be associated with various domains of earth science such as space science, water, wind and solar power.
The basic objective of system analytics is to analyze complex, dynamic, non-linear and linear interactions in various types of systems and design new structures and policies to improve the behavior of a system. A system is associated with a problem oriented model; the basic building blocks of system dynamics are cause effects analysis, positive and negative feedback loops and physical and information flows. The basic functions of system analytics include defining a problem and model boundary, building model, testing and validation of a model, model analysis, evaluation of policy alternatives and recommendation of most viable R&D policy related to technological innovations.

System Analytics

***Agents*: System analysts, business analysts, technology management consultants;**
***Objects / entities*: sustainable smart cities, smart villages, communities, smart world, smart universe;**
***Moves* : Requirements engineering, system design, coding, prototype testing, erection, installation, testing, commissioning**
***Emerging technologies*: Innovate a set of emerging technologies based on global security parameters and sustainable development goals. /* Refer to scope analytics, section 1 */**

- **Poverty control**
    - **Food and beverage security (zero hunger):Automation in agricultural engineering and animal husbandries (dairy, poultry, epiculture, sericulture), biotechnology, genetic engineering (seeds), (chemical (organic fertilizer, paste controllers), electrical (solar water pump), civil, mechanical (solar power enabled tractors), food processing, digital technologies (warehouse management system, ERP, SCM, CPFR);**
    - **Home security : disaster proof nano-housing schema, roof-top solar panels, civil, mechanical, metallurgical, virtual reality;**
    - **Garments and consumer goods security : chemical (jacket, rain coats), textile, agriculture, process manufacturing, retail;**
    - **Education security : digital technology, innovation on education policy (TQM), education methodology, education technology, education materials;**
    - **Healthcare security (good health, well being, family planning, population control): Biomedical technology (laser, surgical robotics), life-science, pharmaceutical, pharmacy, biotechnology, digital technology, artificial intelligence (artificial immune system, soft computing and machine learning, deep learning, case based reasoning), precision medicine, genomics), technology related to R&D**

on biological science (biology, botany, zoology, human physiology, microscope), mechatronics;

- **Financial security (banking, financial services, tax, insurance, retirement planning, stock and derivative trading, economic growth) : Digital technology, information and communication technology, computers, electrical (solar power), electronics, civil, mechanical;**
- **Energy security (clean and affordable renewable energy) : solar microgrid, wind power, power plant technology, mechanical, civil, digital technology (AI enabled smart grid);**
- **Utilities security (clean water and sanitation, gas, computing, internet, telecom): Petrochemical, chemical, electrical (solar power enabled induction cooker), water purifier, wireless communication;**
- **Communication security: web technology, internet, broadcast communication, satellite communication;**
- **Logistics security (travel, hospitalities, surface, water, rail, water): Electrical and hybrid vehicles, Automobile technology, mechanical, electrical (electrical cycles and scooters, solar power enabled battery charging), metallurgy, chemical (carbon), water cycles, water scooters, drones, electronics (sensors, global positioning system), digital (Driver advice system);**
- **Information, media and entertainment security : digital technology (SOC, SOA), cloud computing, quantum computing, secure adaptive filter, solar computing, soft computing, AI, deep analytics, data science, business intelligence, electronics (smart TV, smart phones);**

- **Social security (HR security, decent work, religious and cultural security, gender equality, child security, women's empowerment, peace, justice, partnership, regulatory compliance, strong institutions): digital technology (E-Governance, Social networking, e-court, AI enabled legal system, case based reasoning);**
- **Natural disaster security (climate change, flood, drought, storm, cyclone, earthquake, volcano, snowfall, rainfall, fire, bushfire, global warming, epidemic, astronomical hazards) (attack of wild animals, insects, paste); artificial disaster security (war, act of terrorism, bioterrorism) : Earth science, artificial rainfall, cloud physics, artificial immune system, real-time moving target search for astronomical hazards, music system;**
- **Responsible consumption and production : digital technology (ERP, SCM);**
- **Industry, innovation and infrastructure (smart cities, smart villages): civil, mechanical, electrical, electronics, metallurgy;**
- **Life on land (environmental pollution, conservation of resources and forest, population control): environmental engineering, sensors, earth science;**
- **Life below water (marine life, water pollution, global warming, oil leakage, nuclear explosion): environmental engineering, sensors, earth science, marine technology;**

Let us explore requirements engineering of technologies for humanity for the people of our society and the planet, now and into the future. At its heart are the aforesaid sustainable development goals which are an urgent call for action by all developed and developing countries of the world through strategic alliance and global partnership. The fundamental building block of technologies for humanity is business model innovation - how is it possible to create new job opportunities against the threats of environmental pollution (e.g. air, water, soil, sound and light pollution)? Who are the customers and service consumers? Who are the service providers or the selling agents? What do the customers value? What should be the revenue and profit generation streams of an emerging technology? How to deliver value to the customers at appropriate cost? Following table 1.1 outlines a set of global security parameters and related emerging technologies for humanity. The next sessions (2-10) have shown the complexity analysis of these technologies in terms of scope, system, structure, security, strategy, staff-resources and skill-style-support.

4. STRUCTURE

Prof. David Milla is analyzing the third element of deep analytics - structure i.e. the backbone of a system associated with a specific technological innovation [Figure 1.4]. What are the basic elements of the system architecture associated with a technology innovation? It has two critical viewpoints: system architecture and organization structure. The first one considers technological aspects of the system architecture in terms of topology, smart grid and various components of industrial control system such as SCADA, Expert system, DCS, PCS, SIS, BAS and EMS. The topology of a system should be analyzed in terms of nodes, connectivity, type of connections such as P2P or multipoint, layers, interfaces between layers and organization of layers.
For example, OSI model is a layered framework for the design of communication networks of information systems. It has seven layers from bottom to top : physical, data link, network, transport, session, presentation and application layers. A data communication system has five basic components such as message, sender, receiver, transmission medium and protocol. On the basis of nodes and links, the physical topology of a communication network can be classified into four categories such as mesh, ring, star and bus. The second viewpoint is organization structure – what type of structure is suitable for specific technological innovation; it may be functional, divisional, matrix or network structure. Is there any link between technology and organization structure? It depends on the characteristics of business model.

Another view of structure should be explored in terms of organization structure, size of a firm, economies of scale in R&D, access to complementary resources such as capital and market, governance mechanisms and organizational learning. There are various types of organization structure such as divisional and networked models. The efficiency and creativity of innovation model is closely associated with different types of structural dimensions such as formalization, standardization, centralization, decentralization and loosely coupled networks within and between

firms. Global firms should consider several critical factors such as knowledge, resources and technological diffusion to conduct R&D activities.

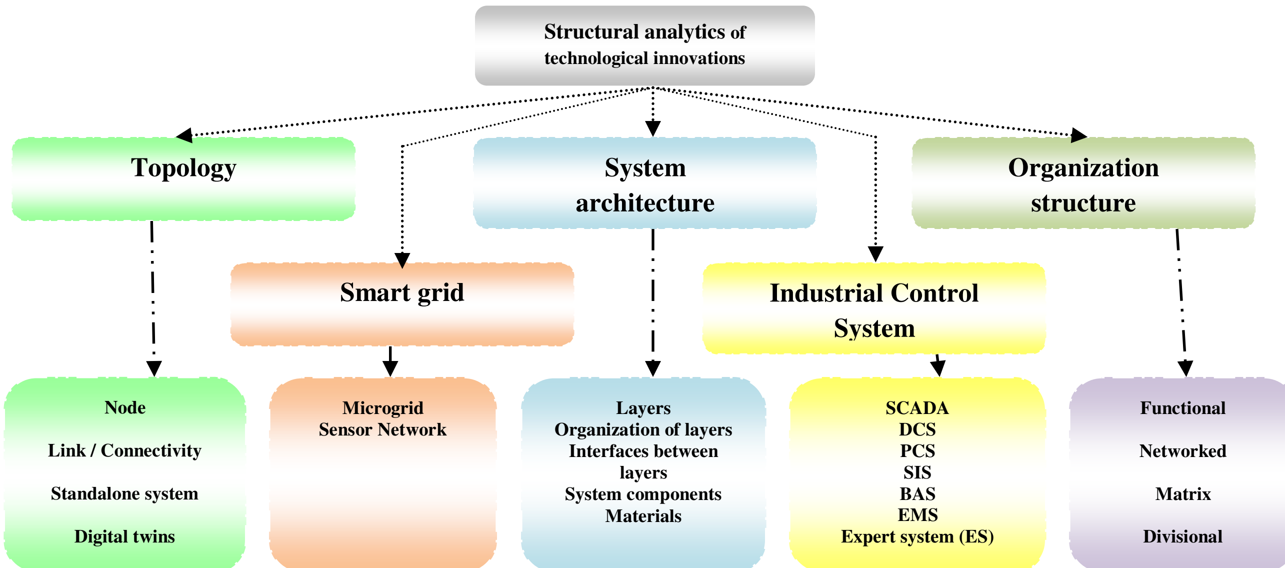

Figure 1.4: Structure analytics

How is it possible to represent the structure of a system associated with a technology innovation correctly and transparently? Digital twins may be an interesting solution; it integrates the concept of industrial IoT, AI, machine learning and software analytics to optimize the operation and maintenance of physical assets, systems and manufacturing processes. A digital twin is the digital replica of a living or non-living physical entity (e.g. physical asset, process, agent, place, system, device); it is expected to bridge and support data sharing between the physical and virtual entities. Digital twins can learn from multiple sources such as itself through sensors, historical time series data, experts and other nodes of the networking schema of the system and get updated continuously to represent real-time status, working conditions or positions.

The concept of digital twins are expected to be useful for manufacturing, energy (e.g. HVAC control systems), utilities, healthcare and automotive industries in terms of connectivity, digital traces and product life-cycle management. The concept can be used for 3D modeling to create digital companions of the physical objects i.e. an up-to-date and accurate copy of the properties and states of the objects (e.g. shape, position, gesture, status, motion) based on the data collected by the sensors attached to the system. It may be useful for the maintenance of power generation equipment such as turbines, jet engines and locomotives; monitoring, diagnostics and prognostics to optimize asset performance and utilization through root cause analysis and to overcome the challenges in system development, testing, verification and validation for automotive applications. The physical objects are virtualized and can be represented as digital twin models seamlessly and closely integrated in both physical and cyber spaces. Digital twins should represent the structure of a product innovation intelligently through various phases of the product life-cycle.