Complex Analysis in Business Information Flow – Need for a CFOs Deep Learning Ledger

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***Abstract*— Information flow and the corresponding Business Information Flow Threats/Risks are key parameters in this Internet age. It has been noted that Information Flow and Business Information Flow risks are analysed in Solos. Further, it is surprising to note that the Flow of Business Information as well as the Business Information Flow controls that are defined around it has not been studied as a Mathematical Structure as a whole by CFO and the Business Information Flow/IT Audit/Compliance Team. In this paper we shall see the overview of the same to convert a normal information flow to a Mathematical structure of data which can be aligned/reviewed by the various stakeholders. We shall review the flow specific to the two areas of Mathematics.**

***Keywords*—mathematical structures, surfaces and curves, vector and tensor calculus**

I. Introduction

Even in the 21st Century when the Information and Business Information Flow are driving the enterprises, the analysis and control of the same is driven mainly through Qualitative and Logical Processes. Though IT Audit and Compliance are aligned with the Business Controls/Audit, the level of mathematical analysis and expertise needed is very minimal to drive the process. It would be imperative to say that the CFO or the respective Digital Information Protectors are aware of any of the below common terms which can bring in lots of value into the process:

- The importance of Square of -1 or the Imaginary numbers
- Linear Algebra and Vector Analysis
- Dynamics

In order to mitigate the threats that occur in the 21st Century and beyond there is a need to convert the Dynamical Information flow across the enterprise in terms of Algebraic structures to analysis and behave one step above the malicious entities. (Radhakrishnan, 2024)

There is a need for the CFO/IT Audit and Compliance Team to maintain a Mathematical Ledger of the Process flows to track/control the risks. The maturity should be defined on the level of mathematical knowledge and implementations.

II. Information Flow Innovation

Information flow across the business is through the defined pattern. It depends on the various intermediary assets as defined below:

- Business Applications such as SAP, Oracle, ERP, etc.
- Network Protocols and Rules
- Cloud Integrations
- Database and Data Related Tools
- Other Infrastructural Components
- New Age tools such as DevOps, SRE, AI/MLOps. Etc.

The information flowing across these entities are defined using various rules as well as procured with respect to the Cost/Benefit analysis.

However, in the general practice there are serious Inherent risks in the whole organization of the Information assets: Some are the below:

- No centralized, real-time inventory of the Information assets.
- Non-enablement of Logs or the audit trails at various levels in these assets.
- Monitoring tools maps only the Critical or the Configured assets.
- No Quantitative parameters to check the effectiveness apart from the High/Medium/Low rating or 1–10 scores or similar parameters.
- No centralized end-end flow of packets as vectors across the Organization chain.

Some of the areas that can be enhanced by having the Mathematical structure on the Information flow are the below:

- Viewing the Information flow and the related Business Information Flow risks as a Mathematical Structure
- Viewing the variational analysis of the structure on external and internal parameters
- Identifying transform from one surface to another
- Extending all the applicable mathematical and physical processes into the structure
- Able to identify any potential threats, vulnerabilities, risks and opportunities
- Mapping end-end privacy categorization

The Key problem area is that the Business Processes are not convered into a Mathematical Spherical or Toric Problems hence the tools available in those spaces are not explored. In this paper, we try to address the same.

III. Business Information Flow Innovation

Innovation in Business Information Flow is mandatory in the changing landscape of Digital Systems and Applications. With the vast arena of logs, events and metrics that is enabled or generated, there is a need to review the massive amount of data with mathematical tools rather than qualitative tools. Various ways to bring-in Business Information Flow innovation before rolling out the Mathematical structure of the underlying space is as below:

- Threat modeling as a vector and tensor space rather than mere numbers.
- Risk Management as a dynamical vector systems rather than the multiplicative components of assets and vulnerabilities.

- End-End mapping of the Information flow rather than focusing only on the prioritized systems.
- Extensive usage of Number theory by converting the problem as a Mathematical modeling system.

IV. Mathematical Structural Design

Once we have brought in the required innovation into the Information flow as well as the Business Information Flow domain, the shift should move to the Mathematical structure design and development. The overall process flow of the end-end model can be defined flow diagram as in the Fig. 1.

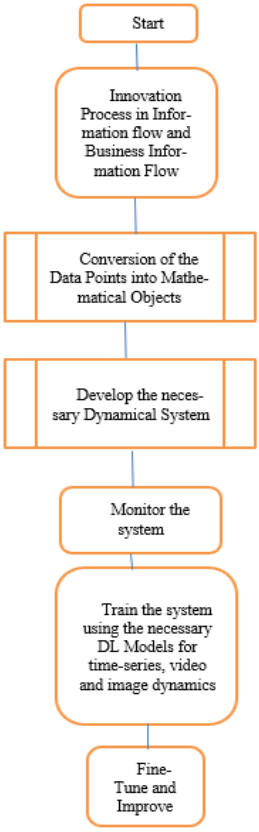

Fig. 1. Flow model.

In the above flow chart innovation is already covered. The rest of the sections are described below:

- Conversion of the Data Points into Mathematical Objects – This is the key step in the entire process, where-in the logs, configurations, policies, etc. are converted into the corresponding mathematical objects and parameters. Some of the examples include:
  - Converting the Firewall, IDS Rules into the Vector controls
  - Time-series log entries are converted into the Dynamical flow of packets or streams
  - Policies are converted into the logical or flow parameters

- Develop the necessary Dynamical System – In this phase the necessary dynamical systems are generated pictorially for analysis. Some of the example dynamical systems are shown in Fig. 2.

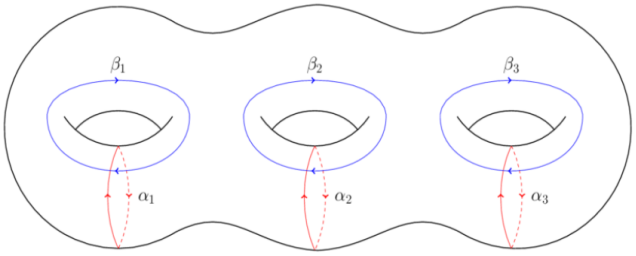

Fig. 2. Sample dynamical systems of the business flow/business information flow controls generated using the data conversion.

Based on the available tools for the reviewer as well as the data at disposal, different structures can be analyzed such as below:

- Spherical systems
- Toroidal systems
- Combinatorial systems
- Specialized systems like Calabi-Yau
- Non-Commutative systems

- Monitor the system–Once the end-end dynamical systems are defined, the monitoring of the flow is performed by various mathematical and physical tools such as:
  - Ergodic dynamics
  - Newtonian/Hamiltonian/Lagrangian dynamics
  - Mapping the surface or structure into the various fundamental domains like Real plane, Complex Plane, Hyperbolic Plane (q-series analysis of the flow)
  - Teichmuller space analysis to get the detailed flow information of Photons or Electrons in the communication
  - Statistical dynamics

Some of the Mathematical references that are checked and analyzed to develop the theory includes the following:

- Dynamical Systems-(Ethan, 1993), (Joseph, 2007), (Nolan, 2018), (Richard, 2010) and (Varopoulos, 2020)
- Analysis-(Whittaker, 1996), (Haboush, 1994)
- Number theoretical domains-(Daniel, 2006), (Deligne, 1982), (Julia, 2021), (Michel, 2001), (Sarnak, 1990), (Robert, 1998)
- Hyperbolic domains-(Andrew, 2006), (Bao, 2009), (Dorina, 2016), (Kathrin, 2017), (Knightly, 2013), (Omeara, 1978), (Lax, 1977), (Ron, 2008)

V. POC Approach

Even though the above mathematical concepts look intimidating, the major summary out of the whole concepts is these steps:

- Identify any Business Problem to solve which is dynamic–Time-series or involves change over a period of time.
- Collate the data related to the Problem in 1 or more

dimension.

- Fine tune the data in the Log or Events collection tools such as OpenTelemetry Tools, Business Application Logs, Network Logs, etc.
- Clean-up the Logs
- Use Data Analytics Techniques of ML to work / enhance / enrich the logs.
- Put the logs/data in to the Mathematical tools such as SAGE/Mathematica, etc., to create a dynamical flow of data across different dimensions. This will create a Toric or Spherical Dynamical systems in the dimensions that is designed for solving the Business Problem. This is a key step where the analysis can be done in Different mathematical models/concepts/domains of expertise.
- Once it is converted and reviewed in the Mathematical tool, it can be modelled for the AI/ML analysis of the Model.
- Once the POC is done, these can be extended to wider scales and wider problems based on complexity of the Use Case.

Example Business Case: Any Business case in any Business domain which has trend or time-series or data having one/more dimensions. This can be HR Data, Sales Data, Financial Data, Inventory/Costing Data, Audit/Compliance Data, Real-time data from the Business Application Logs/Network Logs, etc. These can include Logs from Dynatrace and other Application Log Monitoring Tools as well.

VI. Deep Learning Linkages

Once we map the flow into the Dynamical systems, the following parameters can be controlled:

- Train the system using the necessary DL Models for time-series, video and image dynamics
- Fine-Tune and Improve

If there is a need then new DL Model can be generated or else the existing DL models can be fine-tuned or Federated Learned to solve the dynamical problem. By using DL, we can solve the below problems of the dynamics:

- Predict the future dynamics
- Any malicious activities can be observed in the dynamics like threats, attacks, etc
- Comparing or transforming one dynamical system to another
- Learning the frequency details in the underlying flow of information.

The CFO need to maintain a Ledger of Dynamical information flow and the intelligence that is built into those flows. This will make them compatible to the CFOs and other key stakeholders who analyze the information quantitatively with predictions.

There is a need for aligning the Physics based Deep Learning to the Business Information Flow Domain of Information Flow.

VII. Practical Application

As described in the earlier sections, there need to be a way to practically collate the date and apply the Mathematical/AI-ML Dynamics into the data. In this paper, we propose to represent it in 2 different ways, however in the future research this can be extended to various other Mathematical domains. These 2 areas include the Toric / Spherical Dynamics as well as Symplectic Dynamics. We shall see some of the applications that can be embedded into these spaces:

- Spherical Dynamics: Any Time-series data of any business process can be embedded into the Spherical Domain by giving a periodicity to the process. This can be Employee Attrition, Stock market trends, sales trends, etc.
- Toric Dynamics: In this scenario, we can project 2 or more related/unrelated data in specific timeframes to review their dynamics. This can include Trends within the same timeframes, Dynamics/Threats, Multi-Dimensional Data.
- Symplectic Dynamics: The projected data can be varied based on the inherent features and their changes explored. Trends data can be used here. Sample is shown in Fig. 3.

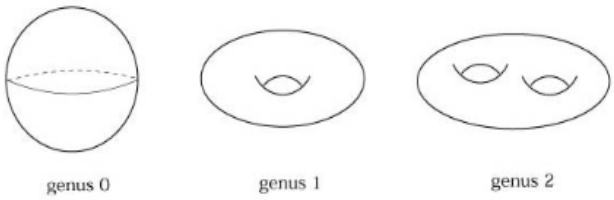

Fig. 3. Projecting 2-dimensional business data as a toric variety.

This can be extended to multiple dimension and different lattices, varieties depending on the data as well as the Business case.

Only through the direction from the CFO/CIO, these initiatives can be prioritized and driven. Hence it needs to be part of their day/to-day Ledgers. Further due to the dynamic threats and opportunities, these needs to be mandatory to bring in value into the process.

VIII. Tools Needed

To do the analysis there can be plethora of tools that can be explored such as Mathematica, SAGE, etc. in the Mathematical side of analysis. In the data collation there needs to be Opensource, Licensed OpenTelemetry Tools. In the AI/ML side, Deep Learning Alogrithms can be used.

There needs to be a sync of all these 3 domains to get the maximum benefit into the process.

IX. Way Forward

Information flow and the corresponding Business Information Flow Threats/Risks once categorized into the mathematical flow, lots of problems can be analyzed and addressed. Some of the problems include:

- Privacy controls
- Enhanced business controls
- Optimization of resources
- Wastage of the underlying assets
- Threats, vulnerabilities and risks controls
- Mathematical savvy enterprise
- Manufacturing, SCADA and other critical infrastructures can be protected effectively

X. New Age CFO Dynamics

There is a need for the new dictionary of work processes for the CFOs and the Information stakeholders which needs to define Information in these new age jargons:

- Workbook–"Business Information Flow for Working Mathematicians" need to be created in the Business Information Flow domain to align and link the Mathematical principles to the Business Information Flow Domain which can act as a Runbook for CFOs and the Business Information Flow team.
- Risk Register that is defined using Complex analysis rather than integers.
- Dynamical flow of packets by analyzing the flow in the Lab setup.
- Like a Financial Ledger there needs to be a Business Information Flow Ledger of Quantitative Risks, entries and matches. This needs to be linked with the AI/ML Intelligence where required.
- Visualization of Information / Packet flow in terms of Complex dynamical systems

XI. Conclusion

This analysis can be extended to other broader domains in the digital age. We can use Digital Innovation into the entire life cycle of the enterprise whereby making the workforce part of the Mathematical landscape.

In the future there is a plan to enhance the process in 2 different ways:

- Create an end-end tool to streamline the flow. This will help the Organization to implement the Dynamical Information Systems on their processes by aligning with the Logs, Events and Traces. Further there is a understanding to integrate it with the best practices such as OpenTelemetry.
- Extend the approach to other Mathematical tools/Models. Once the Mathematical Domain is defined, the extension to other areas of Mathematics can be adhered to. Hence the various Mathematical tools, technologies can be explored to the flow of information. Once that is implemented, then the AI/ML models on the Mathematical data can be rolled out to bring in Value addition to the Organization and the Key financial stakeholders.

The final Objective of the entire exercise is to drive and improve the Organization value chain to the new Age dynamics of data and Intelligence.

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgement

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