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## Interdisciplinary

Designing and Valuating System

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Highlights

Infected Cases of COVID-19

A Systematic Approach to English

Discovering Thoughts, Inventing Future

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# Design Complexity for Objective Function Points

By Paul Cymerman, Joe Van Dyke & Ian Brown

*Abstract-* This paper investigates correlating the basic elements of Unified Modeling Language and Cyclomatic Complexity with Function Point Analysis (FPA) principles to develop an automated software functional sizing tool. This concept has been difficult to achieve due to the logical nature of the FPA sizing methodology versus the physical nature of source lines of code (SLOC). In this approach, we examine software complexity from design and maintainability perspectives in order to understand relationships in physical code. Our hypothesis is that this method will "simulate" FPA principles and produce an objective sizing method. This would provide the foundation for an automated tool that scans physical software code to derive "Objective Function Points" (OFPs) functional size measure.

*GJCST-G Classification:* D.2.9

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# Design Complexity for Objective Function Points

Paul Cymerman [α], Joe Van Dyke [σ] & Ian Brown [ρ]

*Abstract-* This paper investigates correlating the basic elements of Unified Modeling Language and Cyclomatic Complexity with Function Point Analysis (FPA) principles to develop an automated software functional sizing tool. This concept has been difficult to achieve due to the logical nature of the FPA sizing methodology versus the physical nature of source lines of code (SLOC). In this approach, we examine software complexity from design and maintainability perspectives in order to understand relationships in physical code. Our hypothesis is that this method will "simulate" FPA principles and produce an objective sizing method. This would provide the foundation for an automated tool that scans physical software code to derive "Objective Function Points" (OFPs) functional size measure.

## I. Unified Modeling Language Background

We investigated using Unified Modeling Language (UML) [1] to map to Function Points (FPs) [2]. Developed to provide a common language for object- oriented modeling, UML was designed to be extensible in order to satisfy a wide variety of software engineering needs. Like FPs, it was also intended to be independent of any specific programming languages or development methods. [3] Graphical notation represents the UML syntax. UML is defined by the following three categories:

- Static structure diagrams: Describe the structure of a system and include class and object diagrams.
- Behavior diagrams: Describe the behavior /dynamic perspective of a system and include use-case diagrams, interaction diagrams, sequence diagrams, collaborations diagrams, state diagrams and activity diagrams.
- Implementation diagrams: Provide actual source code information including component diagrams and deployment diagrams.

Class diagrams describe the static structure of the model that is objects, classes and relationships between these entities which include generalization and aggregation. They also represent the attributes and operations of the classes.

In order to apply FP concepts in a UML context, we had to translate between the two. To simplify FP terms and definitions into sizing measures that can be easily calculated using a tool, the OFP translation is included in BLUE.

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Record Element Type: Most RETs are dependent on a parent – child relationship. In this case, the child information is a superset where a child class/object inherits all attributes and methods of the parent information. In a parent-child structure, there are one- to-many relationships that define the nature of the connection between attributes within entities [4].

RET ~ INHERITANCE

File Type Referenced: Associations between files provide mapping of maintained files by the application [4]

FTR ~ ASSOCIATION

Data Element Type: UML attributes provide a good indication as to what DETs should be counted in FPA [4].

DET ~ ATTRIBUTES

## II. What is Cyclomatic Complexity?

Cyclomatic Complexity (CC) is a software metric used as a limiting function for measuring the complexity of routines during program development. When the CC of the module exceeds 10 [5], modules are split into smaller modules.

CC is one measure of complexity in software development. This complexity is specific to the ongoing development of routines during overall program development. McCabe references this as Design Complexity (DC) of the Module. It does not address architectural complexity of software design. That would be called the DC of the architecture. The more interactions between objects and the more associations between classes there are, the higher will be the complexity. Both the abstract level of the class as well as the physical level of the objects are taken into consideration. [6]

The following statements from Richard Seidl captures the following rational behind DC:

"UML Design Complexity metrics can be defined as the relationship of entities to relationships. The size of a set is determined by the number of elements in that set. The complexity of a set is a question of the number of relationships between the elements of that set. The more connections or dependencies there are relative to the number of elements, the greater the complexity." [6]

"The more interactions and associations there are between objects and classes, the greater the dependency of those objects and classes upon one another. This mutual dependency is referred to a

coupling. Classes with a high coupling have greater domain impacts" [6]

## III. What is Architecture Design Complexity (DC)?

This DC is a software metric used to understand the Architecture Design – not just for a specific module, but also between modules. This focuses on the Class (a.k.a. Module), Methods (a.k.a. Functions) and Attributes.

A class is a set of objects that have common structure and behavior. A class consists of a collection of states (a.k.a. attributes or properties) and behaviors (a.k.a. methods). A class represents the abstract matrix of an object before it's instantiated, where an object is an instance of a class.

A method is an operation, which can update the value of the certain attributes of an object.

An attribute is an observable property of the objects of a class.

The overall Architecture Design considers the additional relationships:

Association is a relationship between classes which is used to show that instances of classes could be either linked to each other or combined logically or physically through a semantic relationship Inheritance is a form of Association and a feature of object-oriented programming that allows code reusability when a class includes property of another class.

## IV. Deriving Design Complexity of the Architecture

The elementary variables in functions above are designated as DET. The functional complexity is estimated as the total number of user-identifiable groups that exists within DETs and is termed as RET in Data Functions and all referenced file types are counted as FTR in Transactions Functions. A corresponding matrix holds the reference function point values for all function types namely the ILF, EIF, EI, EO and EQ, with respect to the range of DET and RET/FTR in each function. The total sum of the high, medium and low count of all operations is the unadjusted function point count.

The goal is to extract the DC from the complexity fundamentally imbedded in these original relationships. This starts with A.J. Albrecht's original Function Point calculations. There are 3 curves, figure 1, that show how the FPs are calculated based on some level of complexity.

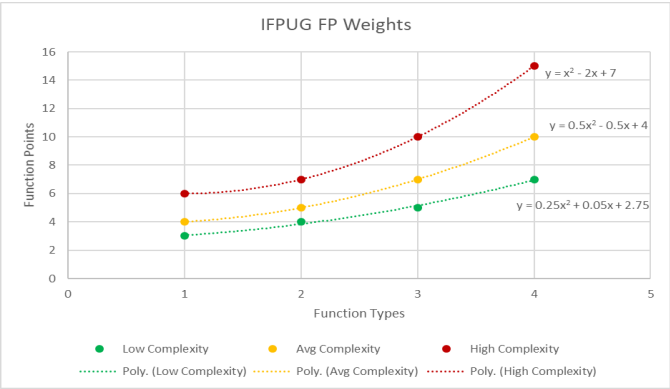


*Figure 1:* FPA Tables to Curves

Mapping the Function Types to Figure 1, we take the "EI" table and map to the complexity value of "1" on the graph. The "EO and EQ" maps to the complexity value of 2. "EIF" maps to a complexity value of 3 and "ILF" maps to a complexity value of 4.

*Hypothesis 1:* Since X-axis references function types that have some inherent complexity, assume this complexity is the development complexity that CC tries to capture. We will shortly address the DC that determines the phase shift of the 3 curves.

McCabe used 4 bins for his Cyclomatic Complexities:

1. CC value 1-10
2. CC value 11-20
3. CC value 21-40
4. CC value >40

If we use these bins as our X-axis values, we can determine the appropriate Function Point value.

Thus, the general form equation from the graphs is:

Function Point = "Coefficient A" * CC^2 + "Coefficient B" * CC + "Coefficient C"

*Hypothesis 2:* Observing the spacing between each of Albrecht's original curves, we can assume that another order of complexity drove these phase shifts. Since the DET, RET and FTR relationships helped build these curves, let's assume that this complexity is the imbedded DC that is used but not specifically referenced. As previously discussed, the DETs, RETs and FTRs are equivalent to ATTRIBUTES, INHERITANCES and ASSOCIATIONS. This would show

how the architecture works together which is the basis for DC. Fitting a quadratic equation:

Function Point = A * CC^2 + B * CC + C

permits DC to be represented by the 3 Coefficients:

A, B, and C.

Next derive the Design Complexity using the values from the 3 curves.

HIGH: $y = x^2 - 2x + 7$

AVG: $y = 0.5x^2 - 0.5x + 4$

LOW: $y = 0.25x^2 + 0.05x + 2.75$

Where x = CC

If we want to model the A Coefficient, we need to look problem in Complexity space where the X-axis is the HIGH, AVG and LOW.

Setting HIGH to 3; AVG to 2; LOW to 1

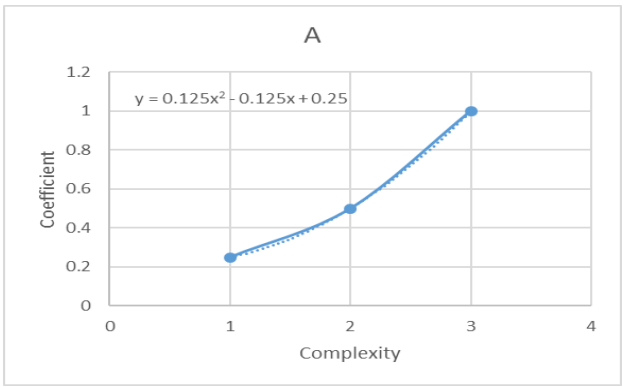


*Figure 2:* "A" Coefficient by Complexity

Following the same process for Coefficient B, we have:

Setting HIGH to 3; AVG to 2; LOW to 1

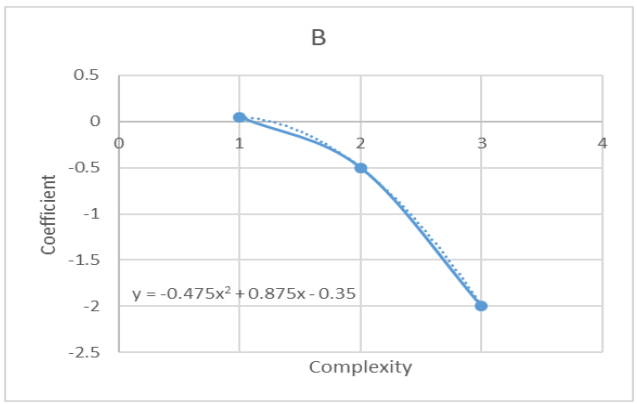


*Figure 3:* "B" Coefficient by Complexity

Following the same process for Coefficient C, we have:

Setting HIGH to 3; AVG to 2; LOW to 1

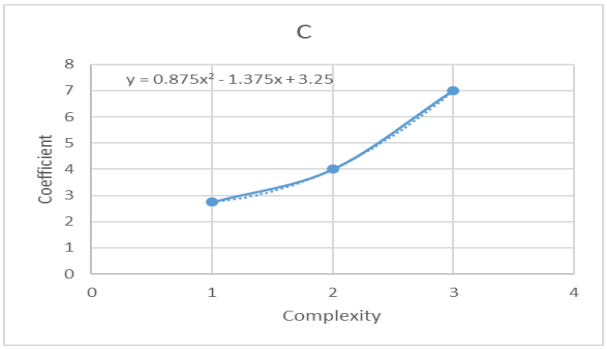


*Figure 4:* "C" Coefficient by Complexity

The complexity on the X-axis is the DC that we are looking for. We now can calculate the coefficients based on DC.

Coefficient A = 0.125 * DC^2 – 0.125 * DC + 0.25

Coefficient B = -0.475 * DC^2 + 0.875 * DC – 0.35

Coefficient C = 0.875 * DC^2 – 1.375 * DC + 3.25

This now leads to a Function Point equation dependent on CC and DC:

Function Point = (0.125 * DC^2 – 0.125 * DC + 0.25) * CC^2 + (-0.475 * DC^2 + 0.875 * DC – 0.35) * CC + (0.875 * DC^2 – 1.375 * DC + 3.25)

Where DC = 1 for LOW; 2 for AVG; 3 for HIGH

## V. Deriving Design Complexity as a Function of Inheritance, Associations and Attributes

Referencing Albrecht's original complexity tables regarding DETs, RETs and FTRs, we can substitute Inheritance for RETs; Associations for FTRs and Attributes for DETs to come up with the following table. To focus on Inheritances, Associations, and Attributes, we are moving from RET, FTR, DET categories to Inheritance, Association, and Attributes categories. For Inheritance and Associations, we need to consider cases where there are values of "0" so we need to adjust the information as follows:

| Category | Low | Avg | High |
|---|---|---|---|
| Inheritance | 0 | 1-4 | >4 |
| Associations | 0-1 | 2 | >2 |
| Attributes | 1-19 | 20-50 | >50 |

The next step is to transform this table into equations. Starting with the Inheritance category, the first row of the table, if we curve fit the values for Inheritance, we will see that the curve, when Inheritance = 0, we intentionally shift the value by 1. Thus, the X-axis is based by Inheritance+1. This technique avoids dealing with a value of 0 which provides a better fit regression curve. When the value on Y-axis is 2 and Inheritance+1 = 1, this translates to LOW complexity.

When Inheritance+1 is ranges 2 to 5, the Y-axis is greater than 2 and less than or equal to 3. This translates to AVG. When X-axis is greater than 5, the Y-axis is greater than 3 which translates into HIGH.

Next we model the Associations category. From Function Point Theory, FTRs are scaled a lot lower than what is seen in today's coding with respect to Associations even though they are similar. One large program shows an average of 2.5 associations, but can range up to 188. This is very common in development and is a result of improved coding practices since 1979 when FPs were first developed. When the value on Y-axis is 1.5 and Association+1 = 1, this translates to LOW complexity. When Association+1 is ranges 2 to 5, the Y-axis is greater than 2 and less than or equal to 3. This translates to AVG. When X-axis is greater than 5, the Y-axis is greater than 3 which translates into HIGH.

Drawing from Function Point mechanics where complexity is the average of [(RET Category DET Category) + (FTR Category DET Category)]

Where:

- (RET Category DET Category) = ∑ (RET Category + DET Category) / 2
- (FTR Category DET Category) = ∑ (FTR Category + DET Category) / 2

Converting RETs, FTRs, and DETS to Inheritances, Associations, and Attributes respectively, we get:

Design Complexity = Average of [(Inheritance Category Attribute Category) + (Association Category Attribute Category)]

Where:

- (Inheritance Category Attribute Category) = ∑ (Inheritance Category + Attribute Category) / 2
- (Association Category Attribute Category) = ∑ (Association Category + Attribute Category) / 2

## VI. Determining the Ranges for Low, Avg, and High Design Complexity Values

To understand the response of the DC equation, we calculated every case within a reasonable range.

By producing all these cases, we can isolate when Design Complexities change in value. We observe a pattern that can be expressed through regression. This regression analysis will provide the bounding limits for Low, Avg and High DC.

## VII. Determining the Missing Data for Calculating Design Complexity Values

We need to transform the matrix to have Attributes inside, Inheritance going across, and the Associations going down. This produces curves showing Attributes as a function of Inheritances. Each curve is phase- shifted due to their dependence on Associations.

Let's focus on the first Attribute Limit equation where the DC = 2 and the Association = 0:

- Attribute_Limit = 27.9 * (Inheritance + 1) ^ - 0.701
  - When Inheritance + 1 = 1, the Attribute_Limit = 28.0
  - When Inheritance + 1 = 2, the Attribute_Limit = 17.0
  - When Inheritance + 1 = 3, the Attribute_Limit = 13.0

Note that 27.9 is the First Term and -0.701 is the Second Term.

We now need to estimate the First and Second Terms as a function of DC using regression

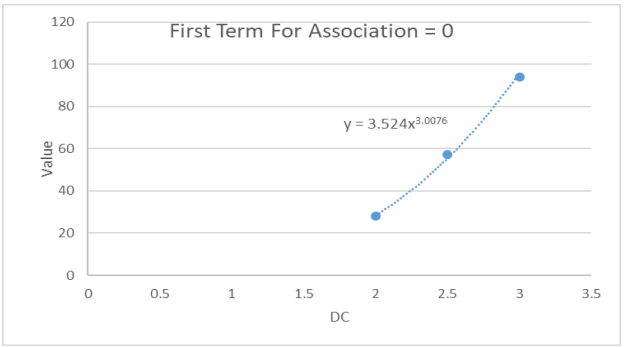


*Figure 5:* First Term Relationship to DC

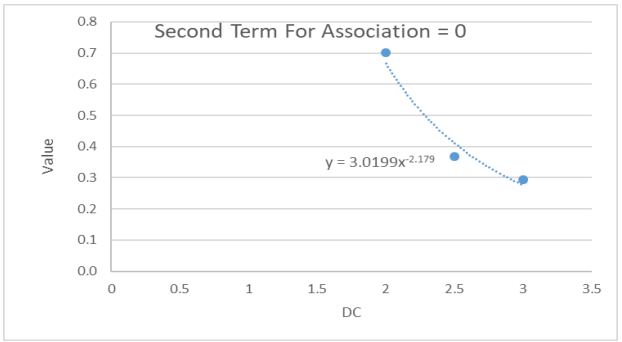


*Figure 6:* Second Term Relationship to DC

Performing this exercise for additional Associations, we get the following values for the First Term:

- First Term (Association = 0) = 3.524
- First Term (Association = 1) = 1.7403
- First Term (Association = 2) = 1.2486
- And so on …

Next is the Second Term:

- Second Term (Association = 0) = 3.0199
- Second Term (Association = 1) = 5.8571
- Second Term (Association = 2) = 8.9756
- And so on …

We now can perform regression to estimate the First and Second Terms as a function of Associations and DC.

## VIII. Transformation to Design Complexity Space

Next step we perform regression based on the previous analysis.

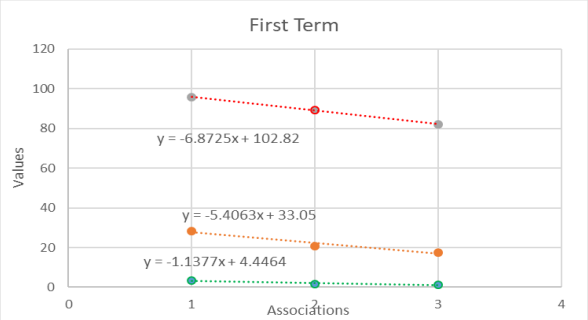


*Figure 7:* First Term Relationship to Associations
Red=HIGH DC; Yellow=AVG DC; Green=LOW DC

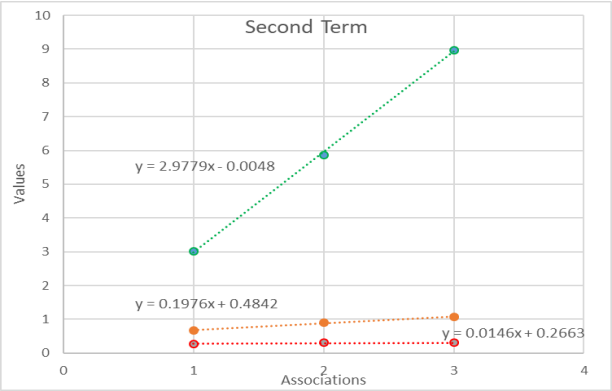


*Figure 8:* Second Term Relationship to Associations
Red=HIGH DC; Yellow=AVG DC; Green=LOW DC

We now can use this information and the original Attribute Limit formula:

- Attribute_Limit = First Term * (Inheritance + 1) ^ -(Second Term)

When DC = 1

- Attribute_Limit_1 = (-1.1377 * Association + 4.4464) * (Inheritance + 1) ^ - (2.9779 * Association + 0.0048)

When DC = 2

- Attribute_Limit_2 = (-5.4063 * Association + 33.05) * (Inheritance + 1) ^ -(0.1976 * Association + 0.4842)

When DC = 3

- Attribute_Limit_3 = (-6.8725 * Association + 102.82) * (Inheritance + 1) ^ - (0.0146 * Association + 0.2663)

We will know the Class DC after we enter the known Inheritance, Associations and Attributes for the specific Class.

- If Attributes < Attribute_Limit_1
  - then DC = 0
- If Attribute_Limit_1 ≤ Attributes < Attribute_Limit_2
  - then DC = 1
- If Attribute_Limit_2 ≤ Attributes < Attribute_Limit_3
  - then DC = 2
- If Attribute_Limit_3 ≤ Attributes
  - then DC = 3

For example:

- Inheritances =1
- Associations = 2
- Attributes = 15

Thus,

- Attribute_Limit_1 = 0.03
- Attribute_Limit_2 = 12.09
- Attribute_Limit_3 = 72.58

Since Attributes = 15, the DC = 2 since Attributes are between 12.09 and 72.58.

This calculates DC for a combination of Inheritances, Associations, and Attributes.

## IX. Using Design Complexity and Cyclomatic Complexity to Calculate Ofps

Going back to previous section where we solved the following equation:

Function Point = (0.125 * DC ^ 2 – 0.125 * DC + 0.25)* CC ^ 2 + (-0.475 * DC ^ 2 + 0.875 * DC – 0.35) * CC +(0.875 * DC ^ 2 – 1.375 * DC + 3.25)

Where:

DC = 1 for LOW; 2 for AVG; 3 for HIGH CC values fall into 4 bins:

1. CC value 1-10
2. CC value 11-20
3. CC value 21-40
4. CC value >40

We now can simplify to a table that provides the OFPs in a simple form:

| OFP | CC_BIN1 | CC_BIN2 | CC_BIN3 | CC_BIN4 |
|---|---|---|---|---|
| DC=0 | 1 | 2 | 3 | 4 |
| DC=1 | 3 | 4 | 5 | 7 |
| DC=2 | 4 | 5 | 7 | 10 |
| DC=3 | 6 | 7 | 10 | 15 |

For example:

- If CC = 7,
  - then CC bin = 1;

- If Inheritances =1; Associations = 2; Attributes = 15
  - then DC = 2,
- Then the OFP = 4

Note that for DC = 0, we needed to minimize the weighting to reflect cases where the design is simplistic in nature. It made little sense to apply a weighting of 3 to a design that had zero Inheritance, zero Associations and zero Attributes. To account for someone thinking of implementing this design, we choose a value of 1 Function Point and went from there using CC.

## X. Summary

This methodology successfully creates a new and simple OFP table that is dependent on CC and DC. We extracted a DC that captures interface relationships based on inheritances, associations and attributes in the actual code. This DC is based on Albrecht's original analysis where DC was a factor but never exclusively identified. This new table is independent of transactional and database qualifiers. Next steps are to incorporate this methodology into an automated Function Point counter that reads actual source code to extract UML definition such as inheritances, associations and attributes to derive the OFPs. This effort is being implemented into the Objective Function Point counter that will reside in the Unified Code Counter Govt (UCC-G) version and the University of Southern California (USC) Unified Code Counter Java version (UCC-J).

## References Références Referencias

1. Rational, UML, 1.1 Notation Guide, Rational Software, 1997.
2. A.J. Albrecht. Function Point Analysis. Encyclopedia of Software Engineering, 1: John Wiley & Sons, 1994.
3. T. Uemura, S. Kusumoto, and K. Inoue, Function Point Measurement Tool for UML Design Specification, Osaka Japan, Nov 1999.
4. I. Brown, Using Entity Relationship Diagrams to Count Data Functions, 2007.
5. McCabe T., "NIST Special Publication 500-235", 1996.
6. Richard Seidl "Modeling Metrics for UML Diagrams", 2010.

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# Designing and Valuating System on Dependability Analysis of Cluster-based Multiprocessor System

By P. Radhika, Dr. Sudarson Jena & Dr. S.V.L Narasimham
*Sambalpur University*

*Abstract-* Analysis of dependability is a significant stage in structuring and examining the safety of protection systems and computer systems. The introduction of virtual machines and multiprocessors leads to increasing the faults of the system, particularly for the failures that are software- induced, affecting the overall dependability. Also, it is different for the successful operation of the safety system at any dynamic stage, since there is a tremendous distinction in the rate of failure among the failures that are induced by the software and the hardware. Thus this paper presents a review or different dependability analysis techniques employed in multiprocessor systems.

*Keywords:* *multiprocessor, fault-tolerant, task scheduling,dependability, reliability.*

*GJCST-G Classification:* *C.1.2*


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P. Radhika [α], Dr. Sudarson Jena [σ] & Dr. S.V.L Narasimham [ρ]

*Abstract-* **Analysis of dependability is a significant stage in structuring and examining the safety of protection systems and computer systems. The introduction of virtual machines and multiprocessors leads to increasing the faults of the system, particularly for the failures that are software- induced, affecting the overall dependability. Also, it is different for the successful operation of the safety system at any dynamic stage, since there is a tremendous distinction in the rate of failure among the failures that are induced by the software and the hardware. Thus this paper presents a review or different dependability analysis techniques employed in multiprocessor systems.**

*Keywords: multiprocessor, fault-tolerant, task scheduling, dependability, reliability.*

## I. Introduction

Distributed Systems comprise of inexactly coupled processors that communicate with each other just by transferring messages and lack of common memory among them, consequently the name multiprocessors. In the course of the most recent years, they have gained popularity as an extremely alluring alternative for quick processing of information in enormous scales data frameworks, for example, factory networking, transportation management, and defense must fulfill the standard requirements bound by service interruption, maintainability, and reliability (Singhal,2011). Enhancement of the multiprocessor reliability with no equipment cost is the most conventional aim. The framework can contain a few programming upgrades with realistic deadlines and various periods where every upgrade in the software is apportioned into a lot of procedures-related by dependencies on the data. Multiprocessors frameworks have developed a ground-breaking means of computation for ongoing applications, for example, those found in atomic plants and procedure control in light of their ability for superior performance and dependability (Sutar et al., 2006).

The quick progression in innovation over the past decade has empowered us to create many advanced frameworks that range from omnipresent handheld gadgets (like tablets and cellphones) to top of the line processing hardware utilized in health care devices, nuclear plants and power systems. Guaranteeing the dependable working of these modern frameworks is a significant concern to significant engineers (Ahmad et al., 2016). Errors in the external factors and the designs, for example, issues in production, disturbances, and damage caused by external factors, cause changes which are not desired in the physical tent of the framework. These issues are particularly hard to display since it is difficult to anticipate their events and impacts. Hence the fault tolerance is critical for improving the dependability by empowering the PC to carry out its functions within the number of specified flaws (Zhao et al., 2013)

Dependability is fundamentally characterized as the capacity of a framework for delivering the services that could be trusted reasonably. Dependability is a concept that has developed from considerations of availability and reliability. Various authors depict the system dependability as the set of traits, for example, integrity, confidentiality, availability, safety, maintainability and reliability. A portion of these traits, for example, availability and reliability are qualitative, while some are quantitative. Reliability investigation is a significant pat of the design and evaluation of a computing model that is fault- tolerant to faults. The primary objective of analyzing the system dependability is the development model representing the time which the entire system fails and the policies about maintaining the assemblies, subassemblies, and components from which the framework is formed (Distefano & Puliafito, 2009). One of the important tasks of analyzing dependability of the fault -tolerant systems is predicting the system reliability for the mission time that were mentioned, which is evaluated by probabilistic measures. A general way to deal with handle this is by combining the models of fault trees and Markov chain, for example, parametric fault-tree (PFT) dynamic (DFT), fault-tree (FT).

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## II. Review of Existing Studies

*a) Fault-tolerant multiprocessor scheduling*

There are many challenges in carrying out scheduling in the multiprocessor environment. The scholars are on the edge of determining answers for these difficulties. Scheduling is the specialty of assigning constrained assets to tasks that are competing over time. A practical schedule fulfills the requirements that are related to a specific sort of resources and tasks to improve the multiprocessor performance (Nirmala and Girijamma, 2014). Numerous methods like genetic and fuzzy algorithms were applied, while a few researchers have also developed probabilistic techniques (Berten et al., 2006) for task scheduling in fault-tolerant systems. Zarinzad et al., (2008) introduced an algorithm for fault-tolerant scheduling dependent on GA. This algorithm was intended for the planning of non-preemptive autonomous tasks for a real-time multiprocessor framework. All the tasks are periodic and expected to have backup and primary copies that are allocated to various processors since the backup is executed just if the primary fails as a result of faults. But this algorithm is appropriate for the planning of the periodic tasks.

Bagheri and Jervan, (2014) tended to the under-usage issue by proposing a mixed critical scheduling technique with the end goal that the performance of the whole system is increased along with meeting the SC task deadlines in the existence of faults. This methodology handles mixed-criticality in assignments as well as in messages between the tasks. The experiments demonstrated the performance enhancement in various run-time execution conditions and with various MC benchmark applications, including a practical robot control framework. Irrespective of the redundancy level, NoC size, and size of the task graph, an improvement in the performance is achieved. Venkataraman et al., (2013) developed a technique for enduring permanent faults in MPSoC framework. The tasks were mapped to MPSoC that they limit the correspondence and overhead mitigation energy. Also, this study also proposed a module for migrating hardware tasks independent of a processor with predictable delay for speeding up the migration of tasks in case of permanent faults in any processor. In comparison to the existing techniques, the proposed technique was quicker when compared to that of migrating the tasks. Further, utilizing a solitary TMM for different processors can be studied, prompting a further reduction of area overhead. Peng, and Yang, (2015) proposed an algorithm RRFTGS for scheduling in fault-tolerant multiprocessor frameworks and also for tests of schedule ability, RRFTGS utilizes both passive and active backups and decides without anyone else which backup should be passive or active. Compared to the approaches that just passive, RRFTGS performed better when the bound was under 0.5. RRFTGS can also manage tasks with usage bound greater than 0.5, while the technique that is just passive cannot. This paper assumed that there is no synchronization between the primary and the backup copies. However, considering synchronization that is present, the processor requesting tolerance to faults will decrease since interference overestimation is decreased.

Chatterjee et al. (2017) developed an improvised dynamic solution for the combined issue of scheduling and application mapping for the multicore platforms based on Noc. The introduced algorithm gives a unified technique for scheduling and mapping for real-time frameworks concentrating on fulfilling application time constraints and reducing the energy for communication; To determine the cores within the system, A prescient model is utilized that is prone to failure for which the allocation of fault-tolerant assets along with task redundancy has to be carried out. By specifically utilizing the policy of the replication, the application reliability, executed on the provided NoC stage, is enhanced. Samal et al. (2019) developed a hybrid GA for PBFTS for multiprocessor conditions. Simulation results show that the methodology has been fruitful in acquiring good outcomes for scheduling the tasks in the range of 10 to 100 and also achieved enormous processor utilization for the fault conditions being simulated. The uniqueness lays on the methodology of hybridizing customary GA utilizing the key thought and the information taken from the scheduling of RT tasks and fault tolerance. This has influenced the execution of the PBFTS by improving the genetic operator design and the complete algorithm by the adoption of chromosomal portrayal. Since there is an increase in the size of the multiprocessor system, odds of processors, turning out to be faulty rises, making it a significant issue for diagnosing the faulty nodes within the framework. Various models have been proposed and considered. Lv et al., (2019) stretched out the threshold for applying the probabilistic algorithm for multiprocessor framework based on the hypercube and analyzed the effectiveness of the algorithm. The investigation shows an exceptionally high pace of accurate diagnosis, for separate as well as a group of nodes. In spite of the examination that is accomplished for a specific standard system (the hypercube), the result can fill in as a valuable reference and can add insights into the viability of the probabilistic diagnosis for a group of multiprocessor frameworks that are free of triangles.

*b) Dependability analysis of fault-tolerant multiprocessor*

Evaluating the dependability is significant, often an indispensable stage in the process of designing and analyzing the systems (Ditstefano & puliafito, 2007). It is broadly perceived that the assessment of the features of

dependability in PC frameworks is a complicated task. Conventional procedures which are dependent on simulation and analytical models must be supplemented with experimental techniques that are dependent on estimations, obtained from the models from real frameworks. The above methods including field measurements, robustness testing, injection of faults, have been broadly used to access explicit mechanism of fault tolerance, validating the robustness of the components of the software, or to evaluate the general effect of the framework (Pinter et al., 2005).

Bertolino et al., (2011) introduced approaches for monitoring and analyzing connected framework performance and dependability along with their combined utilization. These methodologies need to represent the evolvability and dynamicity of a connected framework. This investigation covered the quantitative evaluation of the properties of performance and dependability via a technique based on the stochastic model. The study initially provided an overview of measurements related to dependability and the approaches based on the stochastic model to give an understanding of the topic. At that point, the proposition in the view of dependability analysis structure for systems that are connected dynamically was portrayed. This structure can be utilized offline for designing the systems (explicitly, in Connect, for the synthesis of Connecter), and online, to consistently to evaluate the behavior of the system and distinguish potential issues emerging at run-time.

Pournaghdali et al., (2013) developed a simulation tool based on the injection of multi-bit faults referred to as VHDLSFI for the model of VHDL. The main objective of this tool development was to infuse multi-bit and single bit fault in the VHDL model of computerized circuits to examine parameters of dependability, for example, error propagation and latency of error propagation. There is an increase in the number of synchronous faults because of higher frequency, lower voltage and decreased code capacitance. Along these lines, studying the impact of multi-bit faults, particularly MB, is challengeable.

Grinschgl et al., (2013) presented a case study on various evaluations of security and dependability. An exceptionally modularized controller for fault injection systems is utilized. The campaigns of fault injection can be executed effectively through a summed up interface with an elevated level abstraction of physical sources of fault has been demonstrated. The structure is versatile to permit both completely computerized campaigns with a larger memory of fault patterns and more client-controlled campaigns utilizing a little silicon impression. Such full- scale examinations require completely robotized saboteur injection procedures that are presently being developed. Considering such attacks will be important to structure, secure and effective smart card frameworks are additionally valid for a profoundly coordinated framework or framework under high stress from the environment.

Nguyen et al,. (2014), utilizing Petri Nets, introduced a methodology for demonstrating the CBTC framework, where the data is communicated using the LTE network. This model permits the consideration of the transmission methodology and to consider the errors or failures of communication framework. It is likewise incredible for analyzing the dependability of the CBTC framework. The outcomes featured the accessibility of the LTE-based on DCS in applications controlling the trains. Suyama and Sebe, (2014) presented another concept of “available state” and utilizing Markov models, the author described the framework for analyzing the dependability for fault-tolerance, and hence it prevails with regards to improving the system practically using constrained integrators. Also, the thought can assimilate fundamental job in setting up the participation with dependability or reliability engineering.

## III. Comparative Analysis

Finally, A comparative table is developed based on the studies discussed above.

| Author | Technique | Applications | Parameters studied | Results obtained |
|---|---|---|---|---|
| Ter et al., (2010) | Self-testing techniques | Satellite Navigation | Reliability, Maintainability, Unavailability | The developed approach enabled quick diagnosis or detection of electronic fault and repair, thus increasing the MPSoc availability. |
| Masci et ., (2011) | Automatic dependability analysis | Dynamic and heterogeneous environments | Sensitivity, message retransmission | Defined the automated process for supporting the dependable connector synthesis. |
| Gultai et al., (2012) | Fuzzy theory | Distributed system | Failure rate, CPU Time, reliability | Increasing the no of processors. |

| | | | | |
|---|---|---|---|---|
| Miele et al., (2014) | Error analysis and fault injection | Anti-lock braking framework, edge detector | Error propagation | The experimental outcomes demonstrated the effectiveness of the technique in producing a precise dependability report focusing on the criticalities of the system application as well as architecture. |
| Nguyen et al., (2014) | Petrinet modelling | Train control | Mean values of Down and Up Times, Mean Time to First Failure | The outcomes highlighted the availability of the LTE-based DCS in train control application. |

## IV. Conclusion

Analyzing dependability in the process of designing and evaluating the systems is crucial since the introduction of computing systems for automating the processes results in increasing the system complexity thus, affecting the dependability. This paper reviewed different dependability analysis techniques for fault- tolerant multiprocessor. It was observed that the techniques like Petri nets, Markov chains, DFT, Fuzzy theory conveniently supported the dependability analysis for fault- tolerant systems. Finally, it, ought to be focused on the hypothetical action that is identified with the advancement of models of dependability. It is crucial for adapting to the increased complexity of the fault-tolerant frameworks but, for this to be fruitful and applicable, practically one must continue together with actually implementing the frameworks that are tolerant to faults and with the information on experimental data with respect to the features of performance and rate of failure of the integrated modules in the process of FT realization.

## References Références Referencias


1. Singhal, V. (2011). Distributed systems computing upgradation & reliability tecnia Journal of Management Studies, 6(2), 61.
2. Sutar, S., Sawant, J, & Jadhav, J. (2006). Task scheduling for multiprocessor systems using memetic algorithms. In 4th International Working Conference Performance Modeling and Evaluation of Heterogeneous Network (HETNET '06).
3. Ahmad, W. Hasan &Tahar, S (2016, July). Formal dependability modeling and analysis .A Survey. In International Conference on Intelligent Computer Mathematics (pp. 132-147), Springer, Cham.
4. Zhu, F. Jin, H. Zou, D., & Qin, P. (2014). Dependability analysis for fault tolerant computer systems using dynamic and graphs, China Communications, 11(9),16-30.
5. Distefano, S, & Puliafito, A. (2009) Dependability evaluation with dynamic reliability block diagrams and dynamic fault trees. IEEE Transactions on Dependable and Secure Computing, 61.4-17.
6. Nirmala, H. Girijamma. H. A. (2014). Fuzzy scheduling algorithm for real time multiprocessor system. Int. J. Sc Eng Res, 5(7).
7. L, M, Zhou, S. Sun, X., Lian, G., Liu, J., & Wang. D. (2019). Probabilistic diagnosis of clustered faults for hypercube-based multiprocessor system. Theoretical Computer Science, 793,113-131.
8. Samal, A. K, Mall, R, & Tripathy, C. (2014). Fault tolerant scheduling of hard real-time tasks on multiprocessor system using a hybrid genetic algorithm. Swarm and Evolutionary Computation, 14, 92- 105.
9. Zarinzad, G., masoud Rahmani, A., & Dayhim, N. (2008, November). A novel intelligent algorithm for fault-tolerant task scheduling in real-time multiprocessor system In2008 Third International Conference on Convergence and Hybrid Information Technology (Vol. 2. pp: 816-821). IEEE.
10. Peeg, H. &Yang. F. (2015, July). Fault Tolerant Global Scheduling for Multiprocessor Hard Real Time Systems. In First International Conference on Information Sciences, Machinery, Materials and Energy. Atlantis Press.
11. Chatterjee N., Paul, S., & Chattopadhyay, S. (2017) Fault-tolerant dynamic task mapping and scheduling for network-on-chip-based multicore platform. ACM Transactions on Embedded Computing Systems (TECS), 16(4),108.
12. Berten, V. Goossens, J., & Jeannot, E. (2006, April). A probabilistic approach for fault tolerant multiprocessor real-time scheduling In Proceedings 20th IEEE International Parallel & Distributed Processing Symposium (pp. 8-pp), IEEE.
13. Pinter, G,Madeira, H.Vieira, M,Majzik,I.. & Patricza, A. (2005, April). A datamining approach to identify key factors in dependability experiments. In European Dependable Computing Conference (pp. 263-280) Springer, Berlin, Heidelberg.
14. Pournaghdali, F. Rajabzadeh, A., & Ahmadi, M. (2013, October). VHDLSFI: A simulation-based multi-bit fault injection for dependability analysis In ICCKE 2013(pp. 354-360). IEEE.
15. Grinschgl, J., Krieg, A., Steyer, C., Weiss, R., Bock, H., Haid, J.,…& Ulbricht. C. (2013) Case study on multiple fault dependability and security valuations Microprocessors and Microsystems,37(2), 218-227.

16. Nguyen, K Beugin, J., Berbineau, M., & Kassab, M. (2014. October). Modelling communication based train control system for dependability analysis of the LTE communication network in train control application. In 2014 European modeling Symposium (pp. 320-325). IEEE.
17. Suyama, K., & Sebe, N. (2014, June). Dependability analysis of fault-tolerant servo systems using limited integrators. In 2014 European Control Conference (ECC) (pp. 652-659), IEEE.
18. Bertolino A. Calabro, A., Di Giandomenico, F., & Nostro, N. (2011, June). Dependability and performance assessment of dynamic connected systems. In International school on formal methods for the design of computer, communication and software systems (pp.350-392). Springer, berlin, Heidelberg.
19. Gulati, S, Yadav. P. K., & Bhatia, K. (2012). A reliability model for the task scheduling in Distributed System based on Fuzzy Theory, CIIT International Journal of Networking and Communication and Engineering, 4(11),684-688.
20. Micle, A. (2014). A fault-injection methodology for the system-level dependability analysis of Multiprocessor embedded systems. Microprocessors and Microsystems, 38(6), 567-580.
21. Distefano, S., & puliafito, A. (2007 March). Dependability modeling and analysis in dynamic system. In 2007 IEEE International Parallel and Distributed Processing Symposium (pp. 1-8). IEEE.
22. Ter Braak. T. D., Burgess. S T, Hurskainen, H., Kerkhoff, H. G., Vermeulen B., & Zhang, X.(2010, September). On-line dependability enhancement of multiprocessor SoCs by resource management. In 2010 International Symposium on System on Chip (pp. 103-110). IEEE.
23. Masci,P., Martinucci, M., & Di Giandomenico, F.(2011, March) Towards automated dependability analysis of dynamically connected systems. In 2011 Tenth International Symposium on Autonomous Decentralized Systems (pp. 139.146), IEEE.
24. Bagheri, M. & Jervan, G. (2014 August). Fault-tolerant scheduling of mixed-critical application on multi-processor platforms. In 2014 12th IEEE International Conference on Embedded and Ubiquitous Computing (pp. 25-32). IEEE.
25. Venkataraman, S., Santos, R., Kumar, A. & Kuijsten, J. (2015, July). Hardware task migration module for improved fault tolerance and predictability. In 2015 International Conference on Embedded Computer Systems: Architectures, Modeling, and Simulation (SAMOS) (pp. 197-202), IEEE.

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# A Distributed-Ledger, Edge-Computing Architecture for Automation and Computer Integration in Semiconductor Manufacturing

By Da-Yin Liao

*Abstract-* Contemporary 300mm semiconductor manufacturing systems have highly automated and digitalized cyber-physical integration. They suffer from the profound problems of integrating large, centralized legacy systems with small islands of automation. With the recent advances in disruptive technologies, semiconductor manufacturing has faced dramatic pressures to reengineer its automation and computer integrated systems. This paper proposes a Distributed-Ledger, Edge-Computing Architecture (DLECA) for automation and computer integration in semiconductor manufacturing. Based on distributed ledger and edge computing technologies, DLECA establishes a decentralized software framework where manufacturing data are stored in distributed ledgers and processed locally by executing smart contracts at the edge nodes. We adopt an important topic of automation and computer integration for semiconductor research & development (R&D) operations as the study vehicle to illustrate the operational structure and functionality, applications, and feasibility of the proposed DLECA software framework.

*Keywords: distributed ledger technology; smart contract; edge computing; automation; computer-integration; semiconductor manufacturing.*

*GJCST-G Classification: C.2.4*

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## I. Introduction

As applications and technologies in semiconductors continue to advance, semiconductor manufacturing must aggressively evolve to fulfill the changing technical and business requirements in the semiconductor industry. Contemporary 300mm semiconductor manufacturing systems have highly automated and digitalized cyber-physical integration. They are an ideal example in realizing *Industrie 4.0*, *Smart Manufacturing,* or *Digital Enterprise* [1-3], all the widely used terms describing *the Factory of the Future*, the convergence of disruptive and innovative technologies of information, operations, and data. While the industry is experiencing its fourth revolution, semiconductor manufacturing systems get prepared in moving forward to their paradigm shift toward the future semiconductor factory (a.k.a. a *wafer fab*, or commonly called a *fab*).

Semiconductor manufacturing deals with the production of integrated circuits (IC) products. Based on semiconductor process technologies, semiconductor manufacturing goes over a sequence of processing stages through circuit design, wafer fabrication, assembly/packaging, and final testing. Semiconductor manufacturing aims to meet all the specified requirements on product functionality, quality, cost, reliability and durability, and regulations on the environment, safety, and health (ESH). Semiconductor manufacturing is a both technology- intensive and capital-intensive business. The fabrication of semiconductor products costs a lot of money. Building a new 300mm production fab now could cost several billion dollars. The investment skyrockets even upwards to twenty billion dollars for the most advanced process node of 3nm semiconductor technology. Semiconductor manufacturers use semiconductor wafers for the fabrication of IC devices. A wafer serves as the substrate for semiconductor devices to build in and upon. It goes through hundreds of processing steps, including processes of oxidation, doping, implantation, etching, deposition, and photolithographic patterning. The entire manufacturing process involves several hundreds of sophisticated equipment (or tools) for processing and metrology of semiconductor wafers [4,5]. Semiconductor wafer fabrication consists of the production of the discrete, batch, and continuous flow processes. Due to the considerations on ergonomics, safety and fab efficiency, 300mm semiconductor manufacturing regards the Automated Material Handling System (AMHS) as a must [6-8].

Effective manufacturing of semiconductor products demands a high level of automation and computer integration in allocation, coordination, and collaboration among system dynamics as well as flows of data, information, command, control, communication, and materials. Automation in semiconductor manufacturing uses a hierarchical control architecture design [9]. In the lower level of the hierarchy, there are embedded controllers that provide real-time control and analysis of fabrication equipment. Each equipment utilizes sensors for *in situ* monitoring and characterization. In the higher level, more complex, context-dependent combination of the operations in process and metrology equipment as well as the movement of materials are handled, sequenced, and executed. International Technology Roadmap for

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Semiconductors 2.0 [10] defines ten functionality areas for fab integration in semiconductor manufacturing. They are *Fab Operations (FO)*, *Production Equipment (PE)*, *Material Handling Systems (MHS)*, *Fab Information & Control Systems (FICS)*, *Facilities*, *Augmenting Reactive with Predictive (ARP)*, *Big Data (BD)*, *Control Systems Architectures (CSA)*, *Environmental Safety and Health (ESH)*, and *Yield Enhancement (YE)*. Among these ten functionality areas, FO is the major driver of requirements and actions for required semiconductor fab services. FICS is the facilitator of the integration in semiconductor manufacturing. It covers computer hardware and software, manufacturing execution and decision support systems, fab scheduling, automation of equipment and material handling systems, and process control. In semiconductor manufacturing practices, FICS is carried out by fab CIM (Computer-Integrated Manufacturing) systems.

Semiconductor equipment automation deals with the control and sequencing of job track in/out, process start/stop in equipment, collection of measurement data, change of processing variables, and selection/validation of processing recipes. To facilitate equipment automation in semiconductor manufacturing, standardization of communication protocols among various semiconductor equipment vendors is crucial. Semiconductor Equipment and Materials International (SEMI) [11] defines a collection of common equipment behaviors and communications capabilities of semiconductor equipment. SEMI published the famous SECS (SEMI Equipment Communications Standard) standards of the SECS-I (also, called SEMI E4) in 1980 and the SECS-II (also called SEMI E5) in 1982, respectively. SECS is a point-to-point, layered protocol via RS-232 serial communication. SECS consists of three levels. They are Message Protocol (SECS-II), Block Transfer Protocol (SECS-I), and Physical Link (RS-232). In 1994, SEMI announced the TCP/IP HSMS (High-Speed SECS Message Services, SEMI E37) standards. HSMS is SECS-II over TCP/IP. In 1992, SEMI announced the GEM (Generic Model for Communications and Control of Manufacturing Equipment, SEMI E30) standard which defines a standard implementation of SECS-II for all semiconductor manufacturing equipment and a generic set of equipment behavior and communications capabilities that provide the functionality and flexibility to support the manufacturing automation programs of semiconductor manufacturers. The GEM standard defines which SECS-II messages should be used, in what situations, and what the resulting activity should be. Integration of equipment of different process types from independent equipment suppliers with the same solution methodology and software is thus possible.

Both SECS and GEM are communication interface protocols used for communication between a semiconductor manufacturing equipment and a fab host computer. The SECS/GEM standards define messages, state machines, and scenarios to enable fab automation software (or Equipment Automation Program, EAP) to control and monitor the manufacturing equipment. EAP automates equipment operations of recipe upload/download, collection of state variables and metrology data, and handling of events and alarms. EAP can also act as the interface between equipment and various fab CIM systems and functions, such as MES (Manufacturing Execution System), RMS (Recipe Management System), SPC (Statistical Process Control), APC (Advanced Process Control), and so on. However, the integration of EAP to fab CIM systems and functions depends on fab operations requirements and limitations on message response times and communication bandwidth. The essence of EAP is a communication gateway coded with the state machine mechanism of operations logic. Basic computing power without local storage is sufficient to execute an EAP. Also, modern Equipment Engineering Systems (EES) require immense quantities of equipment and process data. The collection of specific data from equipment complies with the SEMI Equipment Data Acquisition (EDA, also known as Interface A) standards.

For the past two decades, most 300mm fabs have adopted the SEMATECH CIM Framework [12,13] to promote computer integration on their planning and operations management through object-oriented technologies. The SEMATECH CIM Framework is a software infrastructure with components that provide functionality common across various applications, which are thus integrated by the CIM Framework. The core of the SEMATECH CIM Framework offers a family of abstractions and services to support fab operations and decision making. Applications that utilize these abstractions and services are deployed and executed on a distributed objective-oriented computer platform. The SEMATECH CIM framework addresses the needs to improve the problems of integrating large, monolithic, centralized legacy systems with small islands of automation in semiconductor manufacturing environments.

With the promotion to *the Factory of the Future* in full swing, semiconductor manufacturing has faced dramatic pressures to reengineer its automation and computer-integrated systems. The use of scalable, distributed architecture to decentralize management and control of manufacturing systems has shown promising as an alternative to classical hierarchical control architectures. As the deployment of distributed computing resources in manufacturing systems increases, many efforts on the design of scalable and distributed manufacturing (SDM) systems [14] have proposed to provide more flexibility, traceability, agility, utilization of manufacturing resources, and timely and dynamic control to production. However, building a sound SDM system still faces fierce challenges. They

include (i) the increased system complexity and maintenance efforts, (ii) the difficulty in system synchronization, data consistency and system deployment, (iii) the additional computation and exchange of information, and (iv) the difficulty in security protection and identity verification.

Distributed Ledger Technology (DLT) [15], also better known as blockchain technology (a specific type of DLT) [16], is a disruptive enabling technology that has attracted massive attention and given rise to multiple projects in various industries these years [17,18]. Instead of keeping data centralized in a traditional ledger, DLT stores, shares, and synchronizes transactions in digital ledgers distributed on independent nodes of a network, i.e., a network of distributed ledgers. Especially, each distributed ledger is allowed only to store and organize its data in an append-only mechanism. DLT has features of immutability, transparency, and trustworthiness. It enables transparent, secure, trustworthy, and swift public or private solutions. As a technology establishing a distributed, high-trust data management system, DLT has the potentials for both storing data and increasing the effectiveness of managing the stored data.

DLT classifies and uses three groups of data. They are processing logs, states, and executable code of smart contracts [19]. DLT enables the transitions of state to take place locally and follow the state machine of smart contracts, once some specific criteria met. The decentralized characteristics of DLT enable services or applications (executed via smart contracts) to store and process data close to the place which creates the data. Edge Computing (EC) [20] brings computation and data storage at the edge nodes of a network. Such decentralization of data and their processing at the edge of the network has many advantages of time and cost. Instead of time-consuming operations of forwarding data to the centralized hosts and then processing data in the hosts, EC provides its services and applications closer to end-users with fast processing and quick response time, and with fewer costs required. As processing takes place locally, data are much safer and more private in the EC paradigm.

This paper deals with the design and applications of distributed ledgers and edge computing for automation and computer integration in semiconductor manufacturing. Instead of centralized services provisioning and functions in traditional semiconductor manufacturing systems, we develop a distributed-ledger, edge-computing architecture (DLECA). DLECA utilizes distributed ledger and edge computing technologies to establish a distributed software framework. DLECA stores data in distributed ledgers using a distributed, append-only, time stamped data structure. Data in a distributed ledger are composed of not only its processing requirements and logs; but also complex state variables with smart contracts. State variables are updated dynamically using edge computing of smart contracts once specific criteria met. Such decentralization of data and their processing increases the overall effectiveness and efficiency of planning and operations management in semiconductor manufacturing. We choose the important topic in pioneering semiconductor manufacturing for automation and computer integration of semiconductor research & development (R&D) operations as the study vehicle to illustrate the operational structure and functionality, applications, and feasibility of the proposed DLECA software framework.

The remainder of this paper is as follows. Section 2 gives a brief overview of automation and computer integration in semiconductor manufacturing first, followed by a review on the technologies of distributed ledgers and edge computing and how these technologies can disrupt automation and computer integration for manufacturing systems. Section 3 describes automation and computer integration in semiconductor manufacturing. Section 4 presents the design of DLECA-based cell controllers as a basis for a distributed-ledger, edge-computing framework for automation and computer integration in semiconductor manufacturing detailed in Section 5. Section 6 describes and analyzes the case study of applying the developed DLECA framework for the management of computer-integrated semiconductor R&D operations and their automation. Section 7 concludes this paper.

## II. Literature Review

Automation and computer integration in semiconductor manufacturing requires seamless communications, coordination, management, and orchestration among materials, equipment, and automated operations within a semiconductor fab. The Microelectronics Manufacturing Science and Technology (MMST) program [21] first designed the well-known Computer-Integrated Manufacturing (CIM) System Framework to meet manufacturing demands on fully integrated dynamic systems. The MMST CIM framework combines the concepts of lean, flexible, and agile manufacturing to define high-quality manufacturing standards. It provides a disruptive approach to semiconductor manufacturing strongly relied on intelligent and flexible systems. Following the MMST CIM System Framework, SEMATECH proposed the CIM Framework Specification [22], an abstract model for semiconductor manufacturing systems. The SEMATECH CIM framework defines a component-based architecture for the next generation of agile MES and focuses on the integration of fab MES applications. As computing technologies continue to move forward, the coverage of fab MES functionalities has changed significantly. Various hierarchical structures have been developed for

vertical integration of fab automation systems into MES to allow for a seamless flow of control and information. In the last decades, both the academic and industrial communities have devoted to the development of advanced CIM architectures that adopt object-oriented and open approaches to integrate several CIM systems from multiple suppliers [23-25]. Lee [26] reviews automation requirements and technologies for semiconductor manufacturing, including fab integration architectures and fab operations with automated material-handling systems (AMHS), communications and networking, fab control application integration, and fab control and management. Liao [9] deals with the automation and integration problems in semiconductor manufacturing and proposes an intelligent AMHS management framework to optimize the integration of fab operations with AMHS. To our best knowledge, neither papers nor research results have been published so far on the design and applications of distributed ledger and edge computing technologies for automation and computer integration in semiconductor manufacturing.

In a manufacturing system, the functionality of MES supports most of its manufacturing processes, from production order release to delivery of finished goods [27]. The increasing use of sensors and high-speed networks has resulted in the continuous generation of big data. It also triggers renowned models in decentralized and distributed manufacturing systems, including the development of scalable distributed manufacturing (SDM) systems [28]. More and more designs of intelligent, distributed, and collaborative control systems have been proposed and put into practice in semiconductor manufacturing. Holonic and multi-agent control systems [29] have features of intelligence, autonomy, coordination, reconfigurability, and extensibility. Along with the tides in industrial digitalization, both academic and industrial research groups have made a lot of efforts in digital manufacturing [30, 31], which utilize a highly promising set of technologies to reduce the time and cost of product development and to provide mass customization of products in high quality and prompt delivery. Bratukhin and Sauter [32] investigate if and how distribution of existing centralized MES functions is possible and reasonable at the expense of increasing coordination and communication among the entities involved. This paper proposes a Distributed-Ledger, Edge-Computing Architecture (DLECA), where MES functionalities are partially distributed to the edge nodes to make decision-making processes more flexible.

Released in 2005, the IEC 61499 Standard [33, 34] provides a generic model for distributed industrial control and automation systems where programmable logic controllers (PLC), intelligent devices and sensors are integrated. The IEC 61499 architecture adopts an event-driven execution mechanism that allows an explicit specification of the execution order of *function blocks*, the fundamental model of the IEC 61499 Standard. Each function block comprises an Execution Control Charts (ECC), which is a state machine and able to trigger the execution of algorithms as defined in the compliant standards. The network of interconnected function blocks form and define the applications. The IEC 61499 Standard is application-centric. In a system, applications are created for the whole system and then distributed to the available devices accordingly. Therefore, the applications are distributed but maintained together. Interested readers can refer to the up-to-date surveys on the automation technologies and architectures of manufacturing control systems in [35,36].

Distributed Ledger Technology (DLT) relies on a distributed, decentralized, peer-to-peer network that utilizes cryptographic hashes and consensuses mechanisms [37]. In a distributed ledger network, a digital ledger is replicated and shared across multiple peer-to-peer participants. Data stored in a distributed ledger are verifiable and unable to change. Blockchain [38] is a data structure that creates a distributed digital ledger. As a subset of DLT, blockchain technology is the underlying technology of Bitcoin [39] and many digital cryptocurrencies. A distributed ledger is programmable with scripting. A smart contract [40], as a scripting code in DLT, is a program of business logic (or a state machine with a set of state-response rules) that autonomously executes based on the defined rules. The potentials and challenges of using blockchain and smart contracts in developing applications for Industry 4.0 are studied and surveyed in [41]. The research of [42] surveys blockchain technology on its working principles and elements in distributed control and cooperative robotics, which highly demands secure and distributed mechanisms.

Based on a hierarchical control structure, Stanciu [43] presents a blockchain-based, distributed control system for edge computing. A three-tier model for edge computing is adopted where devices are at the bottom, a mesh of edge nodes in the middle, and cloud services on the top of the control hierarchy. There are blockchains deployed on the top level, where smart contracts in a blockchain provided as a cloud service make the strategic decisions. The research of [44] proposes a reference architecture for industrial automation. The architecture combines edge computing and blockchain technologies for flexible, scalable, and reliable configuration and orchestration of automation workflows and distributed data analytics. Based on edge computing and blockchain technologies, Isaja and Soldatos [45] introduce the Reference Architecture (RA) and platform design of the H2020 EC co-funded FAR-EDGE project for developing industrial automation systems. The proposed RA provides functionalities in three complementary domains. They are domains of

automation, virtualization of production systems, and data analytics. The RA is composed of four tiers, including Field Tier, Edge Tier, Ledger Tier, and Cloud Tier, from the bottom to the top for describing the structure of a system. This paper adopts a three-layer, hierarchical control model for automation and computer integration in semiconductor manufacturing, detailed in the following sections.

## III. Automation and Computer Integration in Semiconductor Manufacturing

Semiconductor manufacturing systems are large-scale complex systems. Industrial automation and control in large-scale complex manufacturing systems usually bases on distributed hardware with the hierarchical design of automation and control functions. Due to the complexity of fab operations, current practice in semiconductor manufacturing automation systems adopts the classical hierarchical control model in implementing their automation and control functions. The model decomposes a large-scale complex system hierarchically into multiple levels of control subsystems. Control subsystems are linked together using hierarchically integrated control mechanisms where the flow of control is strictly vertical and between adjacent levels with data shared across one or more levels of the hierarchy.

The implementation of existing semiconductor manufacturing automation usually involves the integration of three levels of functions [9]. They are *Fab Automation* at the top, *Cell Automation* in the middle, and *Tool Automation* at the bottom. In the top level, Fab Automation covers system integration, manufacturing execution, scheduling and dispatching, activity management, and preventive maintenance. In the middle level, Cell Automation bridges the information exchange in both directions, manages material movement and control, tool connectivity, and equipment communication and control. Also, Cell Automation executes manufacturing processes and technologies like automatic data collection (ADC), overall equipment effectiveness (OEE), and so on. As the foundation level in the automation hierarchy, Tool Automation automates the processing of equipment to minimize or eliminate misoperations caused by human operator errors. Tool Automation also consists of automation of materials handling and metrology tools, wafer sorters, reticle inspection tools, reticle stockers, wafer stockers, and Automated Materials Handling Systems (AMHS). Figure 1 depicts the hierarchical automation in semiconductor manufacturing.

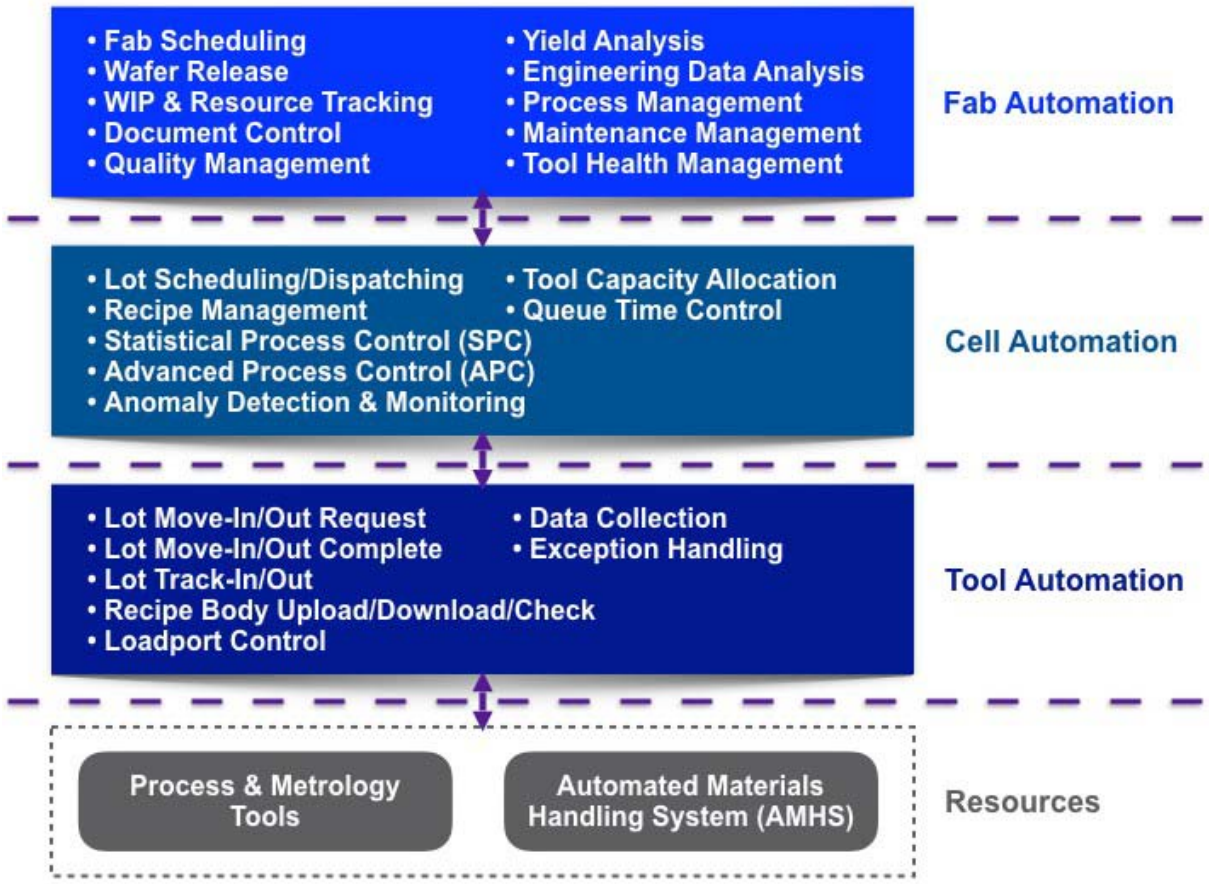


*Figure 1:* Hierarchical Automation in Semiconductor Manufacturing

Semiconductor manufacturing heavily relies on a broad array of computer systems to satisfy customers' requirements. Computer integration in semiconductor manufacturing involves the integration and coordination among diverse computer systems, applications, and a huge amount of data generated during the production of semiconductor products. The SEMATECH CIM Framework [22] provides a reference architecture that integrates and exploits the capabilities of the hardware, software, and production process concepts to enhance overall business performance in semiconductor manufacturing.

Computer integration for Fab Automation includes typical fab MES applications, including factory services, factory management, specification management, yield enhancement, material management, tool management, reporting, and scheduling. These applications are essential elements for vertical integration between the fab shop floor systems and the enterprise systems like ERP (Enterprise Resource Planning), SCM (Supply Chain Management), PDM (Product Development Management), and so on. In modern fabs, applications of Recipe Management System (RMS), Statistical Process Control (SPC), Predictive Maintenance (PdM), Advanced Process Control (APC), Real-Time Dispatching (RTD), and Fault Detection and Classification (FDC) are usually used for Fab Automation. To facilitate the integration of these applications, customized data models are needed to maintain and automate their Extract, Transform, and Load (ETL) capabilities. In practice, the deployment of Fab Automation systems and applications uses centralized computing power on mainframes or computer servers with large, centralized databases such as relational database management systems (RDMS).

Equipment Automation Program (EAP) plays a dominant role in computer integration for Tool Automation. EAP connects the real world (equipment) to the digital world and allows a host computer system to control and automate the processing. An EAP streamlines the business logic (or code) that interacts with the host system and the equipment to control and automate its processing. Each EAP executes based on a SECS driver that provides control and communication interfaces to the controlled equipment and the host system by SECS-defined timed sequences. A typical code of an EAP implements the automated human operations and acknowledgments such as Lot Move-In/Out Request, Lot Move-In/Out Complete, and Lot Track-In/Out; automated step control, and recipe selection and verification such as Recipe Body Upload/Download/Check. An EAP also deals with automated data collection of engineering and equipment statuses and the integration of automated load ports. In an EAP, its business logic includes automated exception handling of equipment alarm notification, logging, and reporting. The deployment of an EAP can use lightweight computing power on a distributed personal computer (PC) in a bus network topology; or on an instance of virtual machine (VM) for deploying and serving as virtual computers.

Operations in semiconductor manufacturing generally take place in a distributed way. Most semiconductor fab operations and decisions are made locally at the physically separated place. Considering the equipment functionality and efficiency in semiconductor manufacturing, the common fab configuration consists of tens of manufacturing cells. Within each manufacturing cell, computer systems are used for planning, controlling, and executing the production activities in the cell. Such manufacturing cells are autonomous, i.e., with the power to self-government. Each manufacturing cell is capable of managing the fabrication of wafers within the cell. The management of fab operations in a manufacturing cell includes dispatching jobs to all workstations in the cell, monitoring the equipment states, and feeding back to its upper-level supervisor systems. Cell Automation provides functionality and applications of tool dispatching, cell scheduling, tool allocation, overall equipment effectiveness (OEE), recipe management, real-time SPC, anomaly detection and classification (ADC), and tool control. Cell Automation may also act as the fab materials management controller and provides functionality and applications of AMHS management, reticle management, OHT (Overhead Hoist Transport) dispatching, and material control. Cell Automation uses small, rugged computers, called cell controllers. A cell controller provides coordination among individual process and metrology tools and their integration with Automated Materials Handling Systems (AMHS) within a cell.

Figure 2 illustrates the applications and functionality in the three hierarchical levels of Fab Automation, Cell Automation, and Tool Automation, which automates and controls the semiconductor manufacturing resources of process and metrology tools, testers, AMHS, and ARMS (Automated Reticle Management Systems). The CORBA (Common Object Request Broker Architecture) Standard [22] is adopted to facilitate the integration and communications among the diverse systems and applications in both Fab Automation and Cell Automation. Except for some legacy equipment models using serial communications (via RS-232 and SECS I for Tool Automation) only, all levels of fab automation and computer integration can now implement on an Ethernet network (via HSMS in Tool Automation). Figure 3 demonstrates a typical network topology used in a semiconductor fab.

In semiconductor manufacturing, cell controllers enable decentralized and distributed decision making at the edge of the fab network backbone. Manufacturing activities that take place in heterogeneous systems or equipment can be coordinated and controlled by

distributed and federated cell controllers to cope with the fast- changing, flexible semiconductor manufacturing environment. The design of distributed cell controllers requires truly distributed workflows and automation logic. This research develops the services and interfaces that implement decentralized, local business logic as smart contracts on top of a distributed ledger for cell controller design. A distributed ledger is a transactional ledger that stores and maintains shared states and data, which are frequently read but infrequently written concurrently by smart contracts. All the smart contracts developed for cell controllers are scenario-specific and able to execute fast and simple logic with associated states and data within the cell scope. Next Section details the structural and functional design of a distributed-ledger, edge-computing architecture. The proposed architecture defines a runtime environment for workflows of edge automation of cell controllers in semiconductor manufacturing.

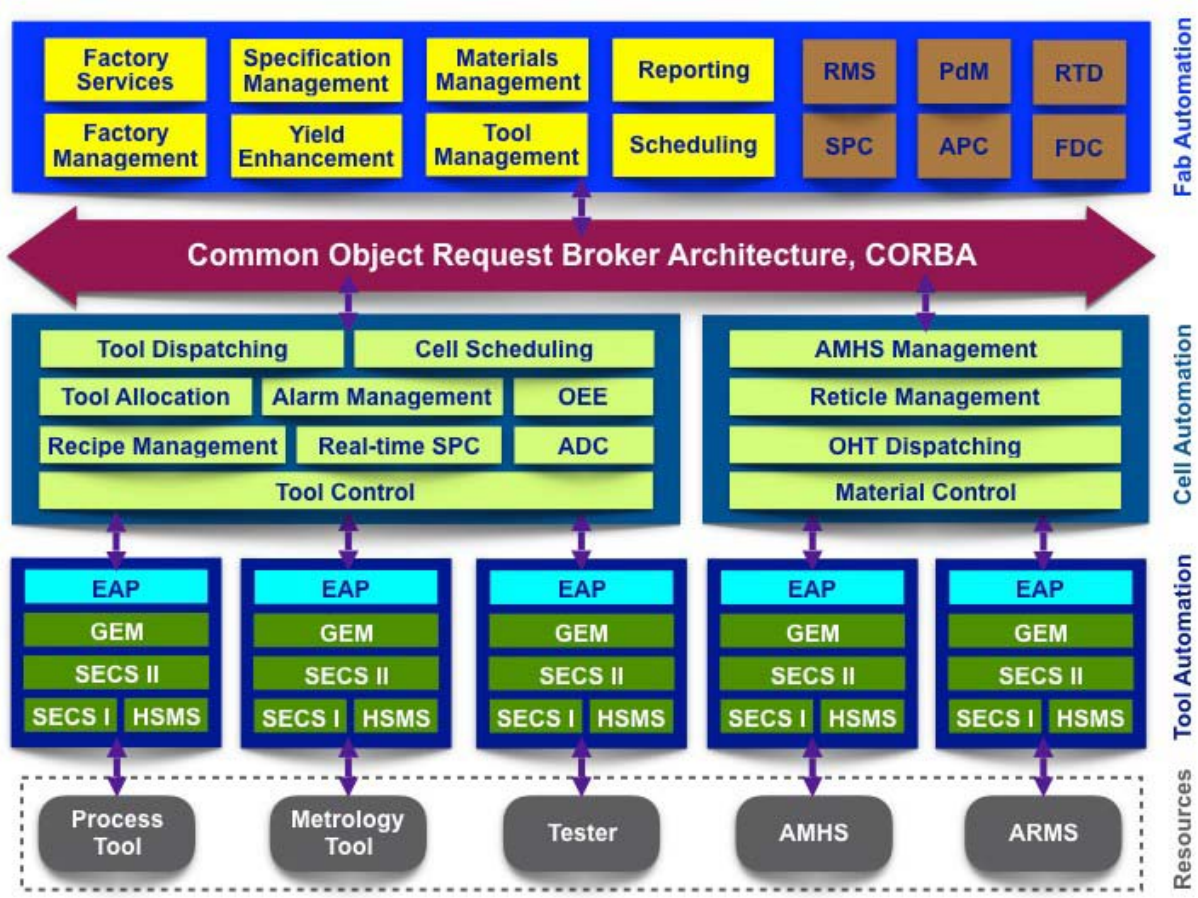


*Figure 2:* Hierarchical Computer Integration in Semiconductor Manufacturing

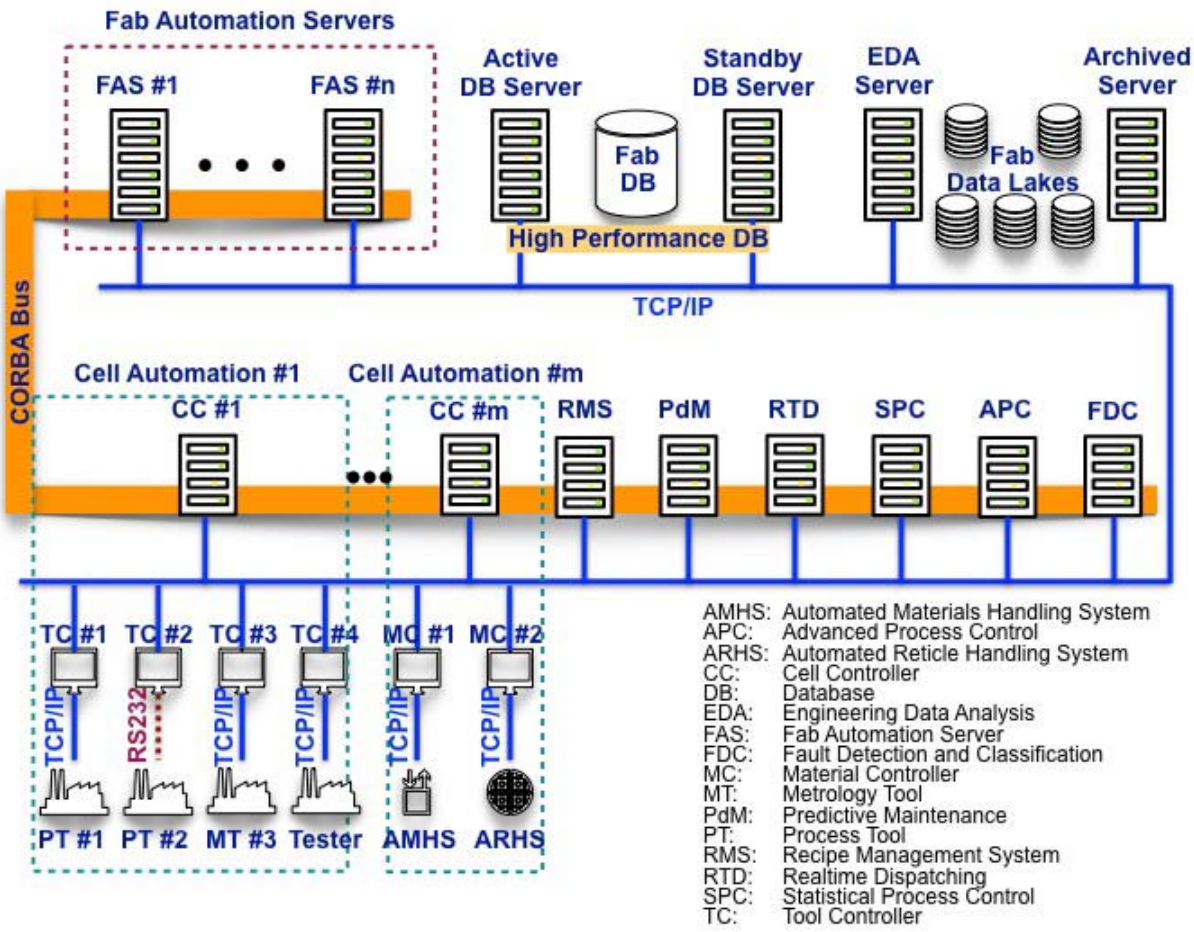


*Figure 3:* A Typical Network Topology in A Semiconductor Fab

## IV. Distributed-ledger, Edge-Computing Architecture (DLECA) for Cell Controller Design

This section describes the design of a distributed-ledger, edge-computing architecture (DLECA) for cell controllers, from both structural and functional points of view. DLECA aims to facilitate efficient and effective automation and computer integration in semiconductor manufacturing. Components in DLECA are stacked into a four-tier structure of Distributed Ledgers, Smart Contracts, Interfaces & Events, and Applications, as shown in Figure 4. The following describes the functions of the components in each tier of DLECA.

*a) Distributed Ledgers*

In this foundational tier, distributed ledgers and their associated services provide the data model, storage mechanism, and their basic CRUD (Create, Read, Update, Delete) operations for cell controllers. A distributed ledger is a shared digital ledger of persistent storage that exists across several locations and among multiple stakeholders of the distributed ledger. Transactions or data updates are only ever stored in the distributed ledger when the stakeholders have reached a consensus. In distributed ledgers, all files are time stamped and given a unique cryptographic signature so that all the data stored are verifiable, auditable, and historically traceable. Different from blockchain as a sequence of blocks of data, distributed ledgers are not required to link into a chain. There are several ways of organizing distributed ledgers. In this paper, we adopt the directed acyclic graph (DAG) data structure in organizing the distributed ledgers in cell controllers. In the DAG data model, all flows of transactions and data updates follow the same direction from earlier to later. This paper defines and uses four classes of distributed ledgers for cell controllers. They are distributed ledgers of *Product*, *Process*, *Resource* and *Service*. The following lists the components and their ingredients in Distributed Ledgers Tier.

- Distributed Ledger Stacks, including
  - core distributed ledger technology
  - storage and database used to store ledgers and data in the distributed ledger network
  - cryptographic processes and signature creation
  - consensus rules
  - peer-to-peer synchronization
  - ability to execute code of smart contracts in the cell controller

- application program interfaces (APIs) that allow data to be read and appended
- Consensus Service, including
  - processes in which an agreement is made on the state of a distributed ledger
  - consensus rules among the stakeholders in the distributed ledger network
  - validator nodes in the distributed ledger network
- Crypto Service, including
  - processes where all records are timestamped with a given unique cryptographic signature
  - processes where all information is securely and accurately stored using cryptography
  - management of keys and cryptographic signatures used for access to data
- Network Protocol, including
  - a set of rules to ensure the data integrity on the distributed ledger network
  - a set of rules to provide network operations with scalability and low end-to-end latency
  - processes that provide peer-to-peer synchronization among the cell controller and others
- Registry Service, including
  - processes that define the registry of ownership of data in a distributed ledger
  - processes that move the registry of ownership of data between distributed ledgers
- New Ledger Service, including
  - processes that create a new ledger on the distributed ledger network
  - a set of rules that define the specifications on a new distributed ledger
  - a set of rules that validate the feasibility of smart contracts associated with a new ledger

*b) Smart Contracts*

In this Smart Contracts tier, ten groups of smart contracts are defined for the provisioning of a combination of fast and simple code snippets (the functions) and data (the states) for processing distributed ledgers at the cell controller. The ten groups of smart contracts are described in the following.

- Execution Management, including
  - code snippets that execute tool automation workflow of the cell controller
  - code snippets that handle exceptions or unexpected events on the cell controller
  - code snippets that monitor the execution and system status of the cell controller
  - code snippets that share the execution and system status to other cell/fab/tool controllers
- Tracking, including
  - code snippets that provide the communications between the cell controller and its tool controllers
  - code snippets that provide the communications between the cell controller and material controllers
  - code snippets that monitor the execution of automated operations from its tool controllers
  - code snippets that monitor the execution of automated materials handling from material controllers
  - code snippets that track products/lots/WIP (Wafers in Process) in the cell
  - code snippets that track quality of products and processes in the cell
- Definition Management, including
  - code snippets that manage the data object attributes in distributed ledgers
  - code snippets that manage information of process/product/recipe/data collection in distributed ledgers
  - code snippets that perform version control of information of process/product/recipe/data collection
  - code snippets that manage process flow/Q-time/batch operations in the cell
- Detailed Scheduling, including
  - code snippets that schedule the materials transport and wafer processing operations in the cell
  - code snippets that allocate capacity to wafer storage and processing in the cell
  - code snippets that generate sequence and timing for tool automation activities in the cell
- Dispatching, including
  - code snippets that prioritize manufacturing sequences of tool automation activities in the cell
  - code snippets that dispatch lots to a tool or a FOUPs (Front Opening Unified Pod) to AMHS
  - code snippets that dispatch tasks to tool and material controllers
- Data Collection, including
  - code snippets that define process data collection specifications
  - code snippets that define measurement data collection specifications
  - code snippets that collect process or measurement data reported by tool automation
  - code snippets that evaluate data based on different specifications of individual tool characteristic
  - code snippets that calculate data collected by specific pre-/post-measurements operations
- Performance Analysis, including
  - code snippets that monitor real-time product and tool status in the cell
  - code snippets that evaluate yields of products and processes in the cell
  - code snippets that evaluate cycle times of products and lots in the cell

- code snippets that evaluate throughputs and OEE in the cell
- code snippets that evaluate anomaly, fault, alarm conditions in the cell

- Resource Management, including
  - code snippets that manage materials handling and processing capacity in the cell
  - code snippets that manage reticles, dummy/control wafer operations in the cell
  - code snippets that schedule preventive maintenance activities in the cell
  - code snippets that execute tool predictive maintenance in the cell
- Data Compiling & Parsing, including
  - code snippets that compile the operations of process and control jobs and send to the tool controller
  - code snippets that compile the operations of material control job and send to the material controller
  - code snippets that compile recipe info and recipe body and send to the tool controller
  - code snippets that parse tool and lot status info and send to other cell and fab controllers
  - code snippets that parse processing results and send to other cell and fab controllers
  - code snippets that parse data collection results and send to other cell and fab controllers
  - code snippets that parse exception handling info and send to other cell and fab controllers
  - code snippets that parse e-Diagnosis info and send to other cell and fab controllers
- Ledger Lifecycle Management, including
  - code snippets that verify the transactions and signatures of a distributed ledger
  - code snippets that trace the lifecycle history of a distributed ledger, from its creation to archive

*c) Interfaces & Events*

In the Interfaces & Events tier, a series of interfaces provide the access to use of distributed ledgers in the cell controllers. Application program interfaces (APIs) are provided to access data of smart contracts in distributed ledgers. Events and their handling services are defined for operations in cell controllers. Services to peer nodes are provided. The interfaces and event handling services of Interfaces & Events Tier are described in the following.

- Distributed Ledger Gateway
  - interface that connect an application program to a distributed ledger
  - interface that consolidate data from multiple distributed ledgers for application programs
  - interface that access data of smart contracts in distributed ledgers
- Data Service
  - processes that provide data of distributed ledgers to application programs
  - processes that provide aggregated data from multiple distributed ledgers for application programs
  - processes that provide data of smart contracts in distributed ledgers
  - processes that review and apply analytic data assessment of distributed ledgers
- Service & Process Automation
  - processes that automate the manufacturing services of cell controllers
  - processes that automate the manufacturing processes of cell controllers
  - processes that manage the automated smart contracts
- Event Handling Service
  - a set of rules that define the events of cell controllers
  - processes that classify the events taking place in cell controllers
  - processes that handle the expected and unexpected events
- Peers Service
  - processes that access its peer-to-peer copies of a distributed ledger
  - processes that ensure peer-to-peer synchronization in the distributed ledge network
  - processes that manage the peer-to-peer network topology of distributed ledgers

*d) Applications*

In the Applications tier, applications are used to manage operations in Cell Automation. The applications commonly deployed to support cell controller functionality include tool dispatching, cell scheduling, tool allocation, overall equipment effectiveness (OEE), recipe management, real-time statical process control (SPC), anomaly detection and classification (ADC), and tool and material control, listed as the follows.

- Tool Dispatching
  - application programs that determine next lot(s) to be processed by a tool when the tool becomes idle
- Cell Scheduling
  - application programs that determine the processing sequence and timing for tools in cell controllers
- Tool Allocation
  - application programs that allocate tool capacity in cell controllers
- Alarm Management
  - application programs that provide actions to mitigate abnormal situations in cell controllers
- Overall Equipment Effectiveness (OEE)
  - application programs that provide visibility to the manufacturing effectiveness in cell controllers

- Anomaly Detection and Classification (ADC)
  - application programs that identify and analyze anomalies in cell controllers
- Real-time Statistical Process Control (SPC)
  - application programs that collect field data and automatically control the processes in real time
- Tool Control
  - application programs that provide logic orchestration through execution of tool automation scenarios
- Material Control
  - application programs that provide logic orchestration through execution of AMHS scenarios

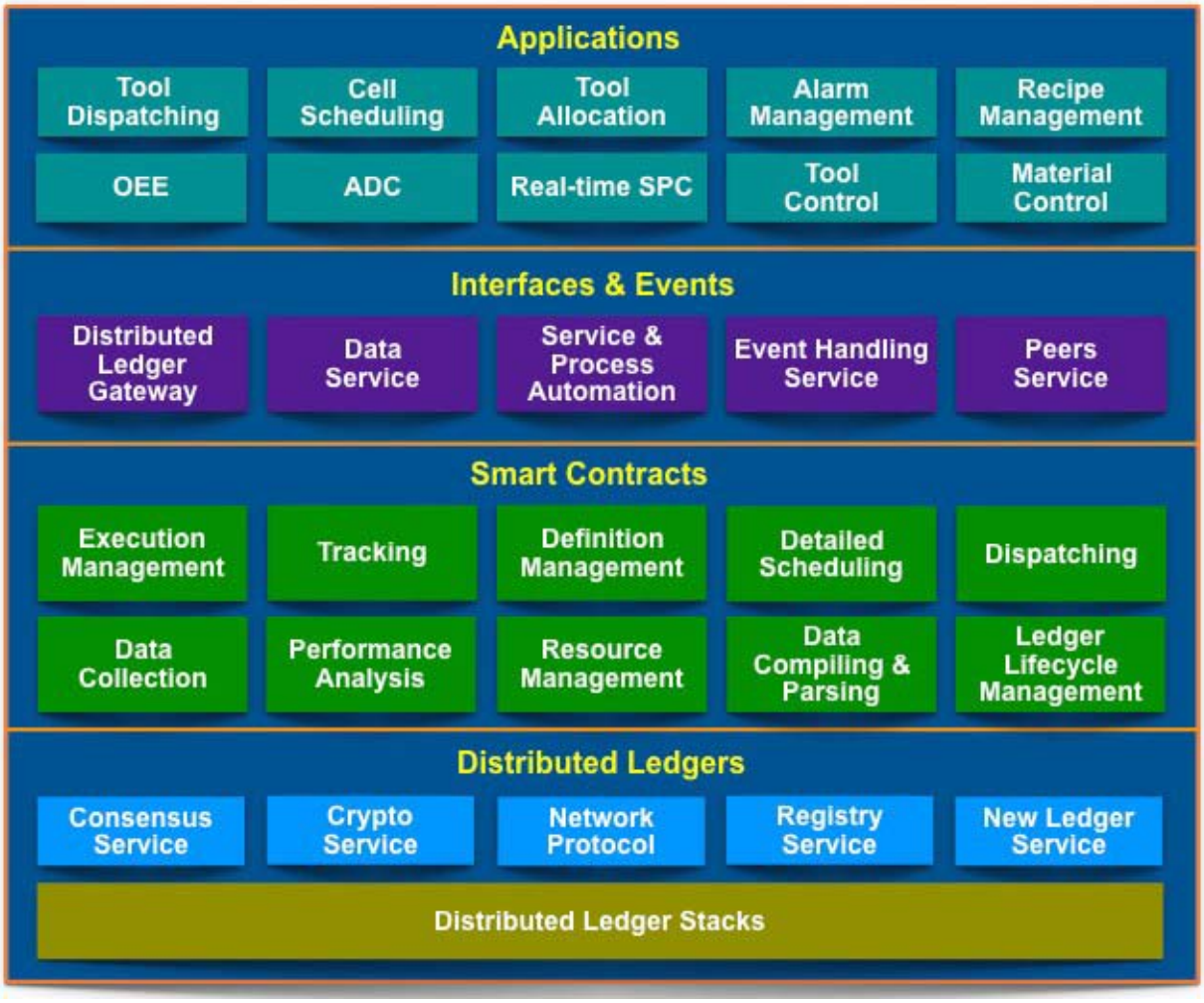


*Figure 4:* A Distributed-Ledger, Edge-Computing Architecture (DLECA) for Cell Controller Design

## V. Distributed-Ledger, Edge-Computing fab Automation and Computer Integration

The proposed distributed-ledger, edge-computing architecture (DLECA) adopts an enterprise, private, permissioned, peer-to-peer distributed ledger network structure. In DLECA, only certain actions can be performed by permitted participants on the network. As an enterprise, private distributed network, DLECA allows only dedicated nodes in the fab network to participate. The permitted nodes include all nodes in the Cell Automation layer and some in the Fab Automation layer. All the cell controllers form the core nodes in DLECA. Nodes of RMS, PdM, RTD, SPC, APC, and FDC servers and other fab automation servers (FAS) are included in DLECA on demand. DLECA maintains the identity of each participant on its network. DLECA is a peer-to-peer (P2P) network. Communications between any two nodes in DLECA are direct and reachable with reachability of one. The upper part of Figure 5 illustrates a complete graph representation of the DLECA peer-to-peer communications topology.

DLECA adopts the Directed Acyclic Graph (DAG) model as the data structure of distributed ledgers. The consensus mechanism under DAG demands newly added data to reference and validate the last two updated data. Such a consensus mechanism allows multiple data to be verified simultaneously. It is simpler and more flexible than other

classic techniques that validate data one at a time. In DLECA, nodes can create data at their discretions at any time. Data inconsistency is possible. Once a conflict occurs, stakeholders or preselected representatives vote to resolve.

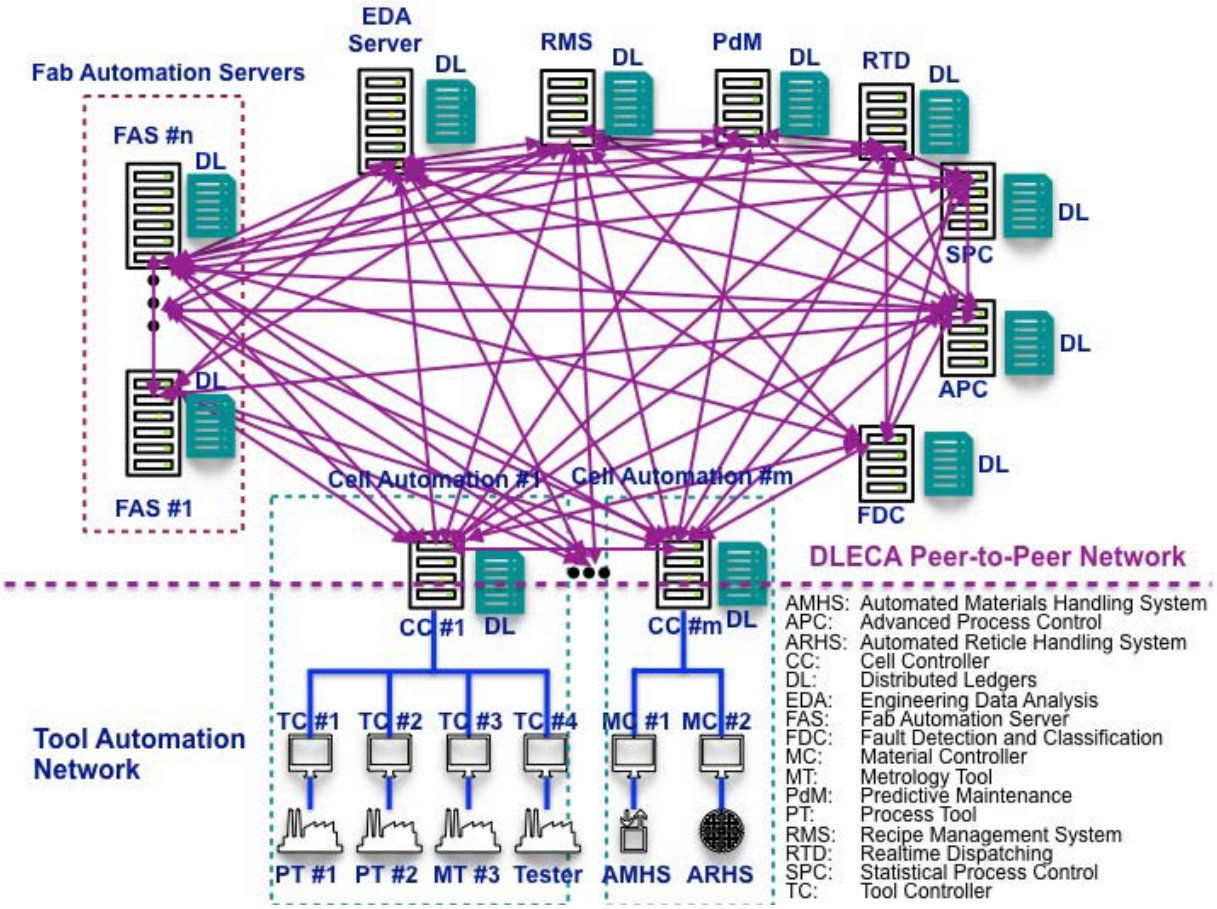


*Figure 5:* The DLECA Peer-to-Peer Communication Network Topology

## VI. Case Study: Automation and Computer Integration for Smart Semiconductor R&D Operations

### a) *Semiconductor R&D Operations*

Semiconductor technology research & development (R&D) is stagnating at the time close to the end of Moore's law. In the era of pushing Moore's law, both materials and equipment are lacking far behind, and product performance gets poor when new complex semiconductor structures increase. On the other hand, in the era post Moore's law, cutting edge research is still seeking opportunities to enable a new era of creativity. As customer and time-to-market pressures become escalating, expedited R&D cycle times, and enhanced learning cycles in the semiconductor industry become more and more crucial. Existing semiconductor fab environments are neither friendly nor flexible enough for R&D operations. Most designs of semiconductor fabs are for production. Even though many of them may share some space to allocate R&D-purposed equipment, their manufacturing systems are production-oriented, which are too rigid and inflexible to cope with R&D experiments and their complexity. New manufacturing systems and automated operations for semiconductor R&D are thus needed.

Compared with semiconductor production operations, activities in semiconductor R&D are more diverse and experiment-oriented. Semiconductor R&D operations have the following characteristics and requirements [46]:

- Wafers of small volume but wide variety.
- Many dedicated machines without backup.
- High production uncertainties such as frequent machine failures and tune-ups.
- Intensive engineering experiments, lot holdings and releases, process changes, inspections, and reworks.
- Complicated lot split/merge operations for the Design of Experiments (DoE) needs.
- Dynamic, on-demand, and floating data items during data collection.
- Few historical data for a new process to reference.
- Lack of baseline and baseline management.

b) *DLECA-based Semiconductor R&D Automation and Computer Integration*

We propose a design for automation and computer integration in semiconductor R&D operations, which bases on the developed distributed-ledger, edge-computer architecture (DLECA). To automate the tedious semiconductor R&D operations and integrate with computer systems, our design proposes three prominent systems. They are the systems of *R&D Workflow Management*, *R&D Data Engineering*, and *R&D Data Engineering.* The *R&D Workflow Management* system rationalizes, streamlines, and automates semiconductor repeated, tedious R&D procedures and operations. The *R&D Data Engineering* system aims to integrate and automate the processes that extract R&D data from various, different sources, then transform and finally load the data into the *Smart R&D Analytics* system that uses AI (artificial intelligence), big data and analytics techniques to accelerate R&D cycles and R&D learning cycles.

Semiconductor R&D operations generate and use massive amount of heterogeneous data distributed in different locations and computer systems. Technology data, parameters, and specifications, such as test vehicles, mask information, process/route/recipe data, and so on, are fundamental to semiconductor R&D operations and execution of R&D workflows. Metrology tools collect the metrology data at different locations, then extract, transform, and load into engineering data lakes for further analysis. The semiconductor R&D process uses a data sheet (also called *runcard*) to detail the processing parameters. We have developed four semiconductor R&D- specific applications for semiconductor R&D Cell Automation, including *Runcard Automation*, *Pilot Run Automation*, *R&D Recipe Management*, and *R&D Route Management*. To support R&D data collection, Tool Automation demands the development of R&D-specific EAPs to provide flexibility and scalability of automated data collection.

Figure 6 shows the design for DLECA-based semiconductor R&D automation and computer integration.

The developed DLECA-based semiconductor R&D automation and computer integration uses two types of R&D distributed ledgers—*R&D Specifications Ledger* and *Metrology/Engineering Ledger*. The R&D specifications ledgers store the primitive data of test vehicles, reticle information, and process/route/recipe data. The Metrology/Engineering ledgers store the generated data produced and collected from the process and metrology tools. We have developed five semiconductor R&D-specific functions for DLECA-based cell controllers. They are *R&D Route Management*, *R&D Recipe Management*, *DoE Template Management*, *Auto Split*, *R&D Runcard Management*. The R&D Route Management function deals with the split/merge operations and data collection of R&D lots. The R&D Recipe Management function controls and validates the feasibility of recipes for processing of R&D operations and experiments. The DoE Template Management function provides DoE templates and transforms templates into processing data for specifications ledgers. The Auto Split function automates inline lot split operations to replace existing engineers' operations. The R&D Runcard Management function manages R&D-specific runcards of process/route/recipe data from their creation to archive.

Figure 7 illustrates the semiconductor R&D-specific design of DLECA-based cell controllers.

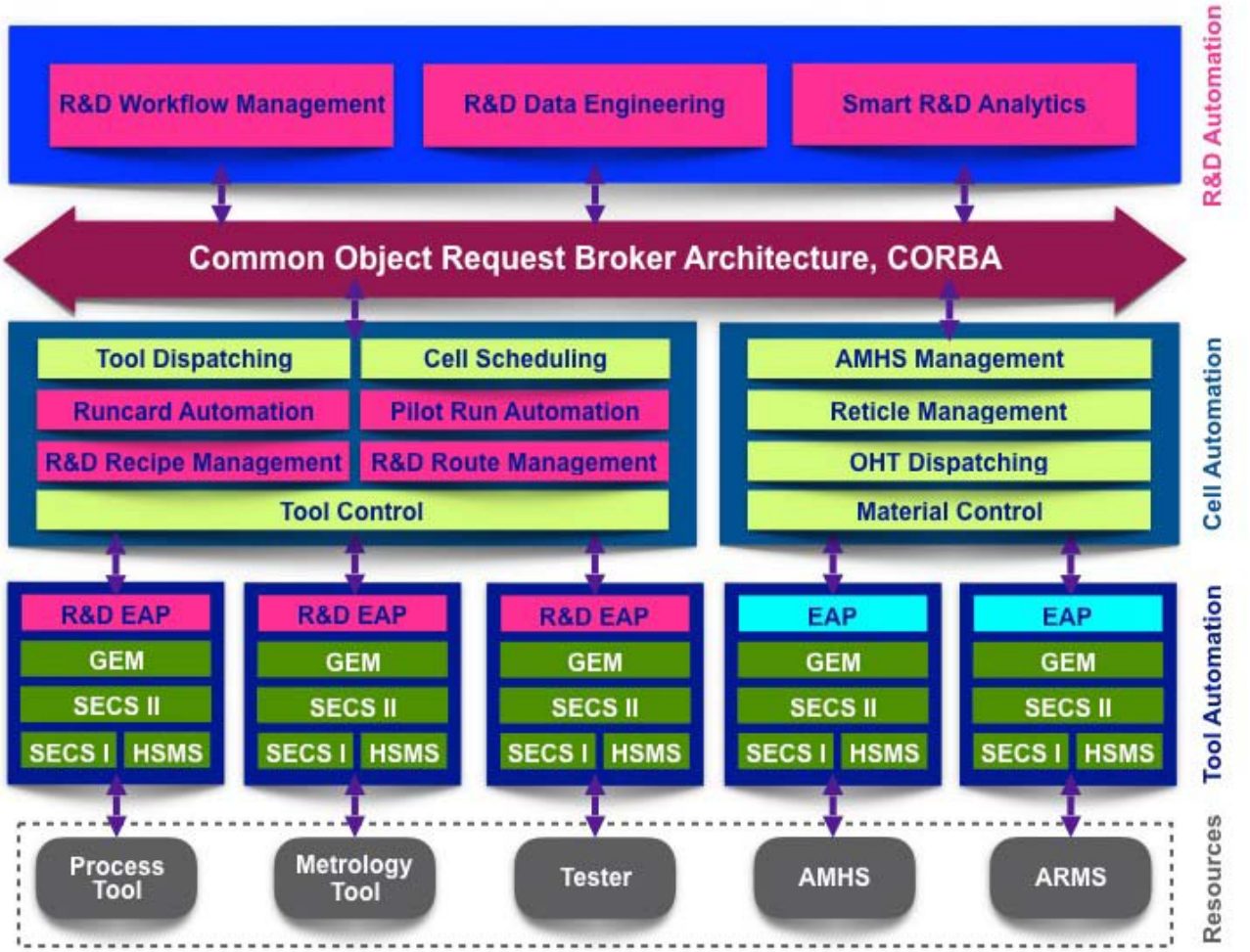


*Figure 6:* DLECA-based Semiconductor R&D Automation and Computer Integration

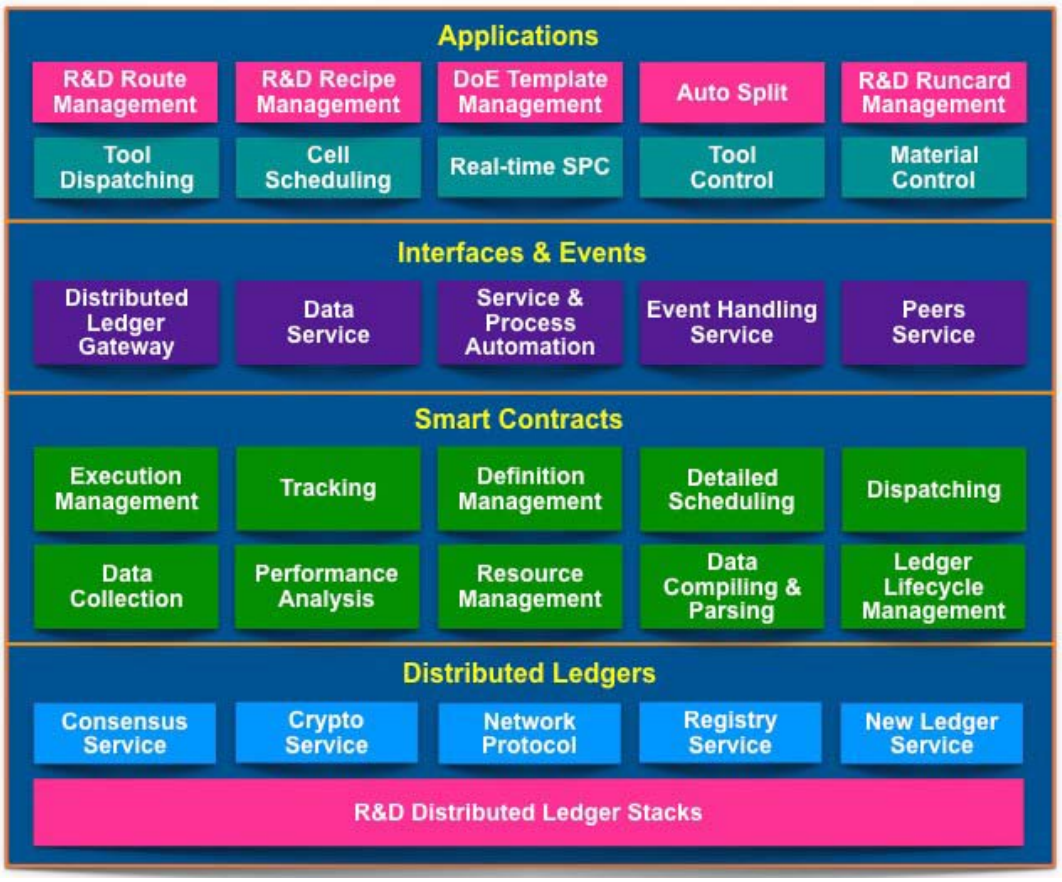


*Figure 7:* DLECA-based Semiconductor R&D Cell Controller Design

## VII. Conclusions

The effectiveness of modern semiconductor manufacturing comes from a high level of automation and computer integration. This paper adopts the disruptive technologies of distributed ledger and edge computing to design a Distributed-Ledger, Edge-Computing Architecture (DLECA) for automation and computer integration in semiconductor manufacturing. DLECA utilizes distributed ledgers to manage the data of processing specifications, requirements, logs, states, and executable smart contracts. When a specified condition happens, smart contrasts of the distributed ledger trigger their edge computing to update state variables accordingly. The decentralization and distribution of data and their processing facilitates the overall effectiveness and efficiency of fab planning and operations management in semiconductor manufacturing. We adopt the important topic in pioneering semiconductor manufacturing for automation and computer integration of semiconductor research & development (R&D) operations as our study vehicle to demonstrate the operational structure and functionality, applications, and feasibility of the proposed DLECA software framework.

The proposed DLECA adopts a hierarchical control architecture stacked by three layers of *Tool Automation*, *Cell Automation* and *Fab Automation*. In DLECA, all the cell controllers in Cell Automation and some fab automation servers in Fab Automation form together as the distributed ledger network and perform edge computing at the edge of the fab backbone. Tool controllers in Tool Automation play a data gateway and control to one equipment only. Such hierarchical decomposition allows one cell controller to coordinate the automation of several associated tool controllers and collaborate with its distributed peers at the same time. As the computing power gets more powerful, in practice, the configuration where a cell controller and its associated tool controllers reside in a single computer is possible and cost-effective in both capital investment and system management. Compared with the traditional two-tier fab automation solutions, the three-layer architecture has more benefits on overall fab effectiveness and efficiency. The distribution and decentralization of fab CIM functionality and applications make fab automation and computer integration more flexible and more agile. Our observations show the increased flexibility and agility in the study case of automated semiconductor R&D operations, which have been considered very challenging and almost impossible. DLECA provides distributed and decentralized processing capability that can collect and process data close to the place which generates these

data, and analyze and react to the analytics of the data timely. All the above expedite the R&D cycle and R&D learning.

We are implementing the proposed DLECA-based framework as part of the Manufacturing IT Architecture for Smart Semiconductor R&D Automation Program in a pioneer 300mm production fab where some of its capacity is allocated for novel technology research and development. The preliminary goal of the Program has three folds: (1) to achieve 95% of automated data collection in R&D activities; (2) to automate all the first-level data analysis; and (3) to automate all the small data analysis with the help of artificial intelligence (AI).

Instead of pushing all the legacy MES functions from Fab Automation to the edge nodes of cell controllers, DLECA only decomposes and moves the Cell-Automation-related data and applications to edge computing, such as cell scheduling and dispatching. Note that the distribution of functionalities in Fab Automation is not always feasible due to their centralized nature. For example, the execution of fab planning in MES or ERP (Enterprise Resource Planning) systems is better in a centralized approach. Further research may consider the problems of determining the optimal or reasonable degree of distribution in decomposing and integrating functionalities of semiconductor legacy centralized computer and automation systems into the DLECA-based automation and computer integration framework.

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## References Références Referencias


1. Hermann, M., Pentek, T., & Otto, B. (2016, January). Design principles for industrie 4.0 scenarios. In *2016 49th Hawaii International Conference on System Sciences (HICSS)*, 3928-3937. IEEE.
2. Thoben, K. D., Wiesner, S., & Wuest, T. (2017). "Industrie 4.0" and smart manufacturing-a review of research issues and application examples. *International Journal of Automation Technology*, *11*(1), 4-16.
3. Kusiak, A. (2018). Smart manufacturing. *International Journal of Production Research*, 56 (1-2), 508-517.
4. Van Zant, P. (2013). *Microchip Fabrication: A Practical Guide to Semiconductor Processing: A Practical Guide to Semiconductor Processing*. McGraw Hill Professional. ISBN: 0071821015.
5. May, G. S., & Spanos, C. J. (2006). *Fundamentals of Semiconductor Manufacturing and Process Control*. John Wiley & Sons. ISBN: 0471784060.
6. Gartland, K. & Kono, S. (1999). *Automated Material Handling System (AMHS) Framework User Requirements Document*: Version 1.0. International SEMATECH.
7. Liao, D. Y., & Fu, H. S. (2004). Speedy delivery-dynamic OHT allocation and dispatching in large-scale, 300-mm AMHS management. *IEEE Robotics & Automation Magazine*, *11*(3), 22-32.
8. Liao, D. Y., & Wang, C. N. (2004). Neural-network-based delivery time estimates for prioritized 300-mm automatic material handling operations. *IEEE Transactions on Semiconductor Manufacturing*, *17*(3), 324-332.
9. Liao, D. Y. (2010, April). Automation and integration in semiconductor manufacturing. In *Semiconductor Technologies*, 39-56. InTech.
10. ITRS (2015). *International Technology Roadmap for Semiconductors 2.0*. http://www.itrs2.net/itrs-reports.html/
11. SEMI. https://www.semi.org/
12. Hawker, J. S. (1998, May). CIM framework architecture and application models. In *International Working Conference on the Design of Information Infrastructure Systems for Manufacturing*, 201-214. Springer, Boston, MA.
13. Doscher, D. (1998). Computer integrated manufacturing (CIM) framework specification version 2.0. *Technology Transfer*. Technology Transfer # 93061697J-ENG. SEMATECH.
14. Hedberg, T., Helu, M., & Sprock, T. (2018, June). A standards and technology roadmap for scalable distributed manufacturing systems. In *ASME 2018 13th International Manufacturing Science and Engineering Conference*. American Society of Mechanical Engineers Digital Collection. [CrossRef]
15. El Ioini, N., & Pahl, C. (2018, October). A review of distributed ledger technologies. In *OTM Confederated International Conferences on the Move to Meaningful Internet Systems,* 277-288. Springer, Cham.
16. Swan, M. (2015) *Blockchain: Blueprint for A New Economy*; O'Reilly: Sebastopol, CA, USA. ISBN 978-1-491-92049-7.
17. Nofer, M., Gomber, P., Hinz, O., & Schiereck, D. (2017). Blockchain. *Business & Information Systems Engineering*, *59*(3), 183-187.
18. Al-Jaroodi, J., & Mohamed, N. (2019). Blockchain in industries: A survey. *IEEE Access*, *7*, 36500-36515.
19. Szabo, N. (1997). Formalizing and Securing Relationships on Public Network. *First Monday*, *2*(2).
20. Shi, W., Cao, J., Zhang, Q., Li, Y., & Xu, L. (2016). Edge computing: vision and challenges. *IEEE Internet of Things Journal*, *3*(5), 637-646.
21. McGehee, J., Hebley, J., & Mahaffey, J. (1994). The MMST computer-integrated manufacturing system framework. *IEEE Transactions on Semiconductor Manufacturing*, *7*(2), 107-116.

22. SEMATECH (1997) *Computer Integrated Manufacturing (CIM) Framework Specification*, Version 1.5, Austin, Texas.
23. Cheng, F. T., Shen, E., Deng, J. Y., & Nguyen, K. (1999). Development of a system framework for the computer-integrated manufacturing execution system: a distributed object-oriented approach. *International Journal of Computer Integrated Manufacturing*, *12*(5), 384-402.
24. Devedžić, V., & Radović, D. (1999). A framework for building intelligent manufacturing systems. *IEEE Transactions on Systems, Man, and Cybernetics, Part C-Applications and Reviews*, *29*(3), 402-419.
25. Lin, C. P., & Jeng, M. (2005). An expanded SEMATECH CIM framework for heterogeneous applications integration. *IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans*, *36*(1), 76-90.
26. Lee, T. E. (2009). Semiconductor manufacturing automation. In *Springer Handbook of Automation*, 911-926. Springer, Berlin, Heidelberg.
27. Saenz de Ugarte, B., Artiba, A., & Pellerin, R. (2009). Manufacturing execution system–a literature review. *Production planning and control*, *20*(6), 525-539.
28. Sprock, T., Sharp, M., Bernstein, W. Z., Brundage, M. P., Helu, M., & Hedberg, T. (2019). Integrated Operations Management for Distributed Manufacturing. *IFAC-Papers OnLine*, *52*(13), 1820-1824.
29. Vrba, P., Tichý, P., Mařík, V., Hall, K. H., Staron, R. J., Maturana, F. P., & Kadera, P. (2010). Rockwell automation's holonic and multiagent control systems compendium. *IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews)*, *41*(1), 14-30.
30. Chryssolouris, G., Mavrikios, D., Papakostas, N., Mourtzis, D., Michalos, G., & Georgoulias, K. (2009). Digital manufacturing: history, perspectives, and outlook. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, *223*(5), 451-462.
31. Balta, E. C., Lin, Y., Barton, K., Tilbury, D. M., & Mao, Z. M. (2018). Production as a service: A digital manufacturing framework for optimizing utilization. *IEEE Transactions on Automation Science and Engineering*, *15*(4), 1483-1493.
32. Bratukhin, A., & Sauter, T. (2011). Functional analysis of manufacturing execution system distribution. *IEEE Transactions on Industrial Informatics*, *7*(4), 740-749.
33. Vyatkin, V. (2007). IEC 61499 Function Blocks For Embedded and Distributed Control Systems Design. *ISA/O3neida, USA*.
34. Zoitl, A., & Lewis, R. (2014). *Modelling Control Systems Using IEC 61499* (95). IET. ISBN 978-1-84919-760-1.
35. Foehr, M., Vollmar, J., Calà, A., Leitão, P., Karnouskos, S., & Colombo, A. W. (2017). Engineering of next generation cyber-physical automation system architectures. In *Multi-Disciplinary Engineering for Cyber-Physical Production Systems* (pp. 185-206). Springer, Cham.
36. Dotoli, M., Fay, A., Miśkowicz, M., & Seatzu, C. (2019). An overview of current technologies and emerging trends in factory automation. *International Journal of Production Research*, *57*(15-16), 5047-5067.
37. El Ioini, N., & Pahl, C. (2018, October). A review of distributed ledger technologies. In *OTM Confederated International Conferences on the Move to Meaningful Internet Systems*, 277-288. Springer, Cham.
38. Iansiti, M.; Lakhani, K. R. (2017) The truth about blockchain. *Harvard Business Review*, *95*(1), 118-127.
39. Nakamoto, S. (2008). A peer-to-peer electronic cash system. *Bitcoin*. Available online: https://bitcoin.org/bitcoin.pdf (accessed on 12 February, 2020).
40. Buterin, V. (2014). A next-generation smart contract and decentralized application platform. *white paper*. Available online: https://cryptorating.eu/whitepapers/Ethereum/Ethereum_white_paper.pdf (accessed on 12 February, 2020)
41. Fernández-Caramés, T. M., & Fraga-Lamas, P. (2019). A review on the application of blockchain to the next generation of cybersecure industry 4.0 smart factories. *IEEE Access*, *7*, 45201-45218.
42. Khan, A. T., Cao, X., Li, S., & Milosevic, Z. (2019). Blockchain Technology with Applications to Distributed Control and Cooperative Robotics: A Survey. *International Journal of Robotics and Control*, *2*(1), 36-48.
43. Stanciu, A. (2017, May). Blockchain based distributed control system for edge computing. In *2017 21st International Conference on Control Systems and Computer Science (CSCS)*, 667-671. IEEE.
44. Isaja, M., Soldatos, J., & Gezer, V. (2017, November). Combining edge computing and blockchains for flexibility and performance in industrial automation. In *International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies (UBICOMM)*.
45. Isaja, M., & Soldatos, J. K. (2018). Distributed ledger architecture for automation, analytics and simulation in industrial environments. *IFAC-PapersOnLine*, *51*(11), 370-375.
46. Liao, D. Y., Chang, S. C., Pei, K. W., & Chang, C. M. (1996). Daily scheduling for R&D semiconductor fabrication. *IEEE transactions on semiconductor manufacturing*, *9*(4), 550-561.

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# A Systematic Approach to English to Bangla Sentence Translator

By Joyassree Sen, Bappa Sarkar, Md. Shamim Hossain & Md. Nazrul Islam

*Islamic University*

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*Keywords: MT (machine translator), parser, lexical analysis, stack, syntax, dictionary.*

*GJCST-G Classification: J.5*


*Strictly as per the compliance and regulations of:*

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*Keywords: MT (machine translator), parser, lexical analysis, stack, syntax, dictionary*.

## I. Introduction

A translator is a program, which reads the source language as input and translates it into target language as output. The goal is to design and build software that will take English contexts as inputs and then analyze, understand them and finally generate Bengali languages, so that eventually we will be able to address our computer as though we were directing another person. By far, the utmost human linguistic communication occurs as speech. Written language is a recent invention and still plays a less central role than articulate sound in most activities. But processing of written is more facile than speech language [1]. For example, the pronunciation of a word differs with person to person, but the structure or component of a word doesn't vary with persons. So the translation of the written form of language can be efficiently programmed. Parser plays a vital role in this translation process. A parser for a grammar (G) is a program that takes a string (W) as an input and produces a parse tree as an output [8]. There are two basic types of parsers, top-down parser, and bottom-up parser. We use top-down parsing. The general parsing process is being illustrated in the following figure.

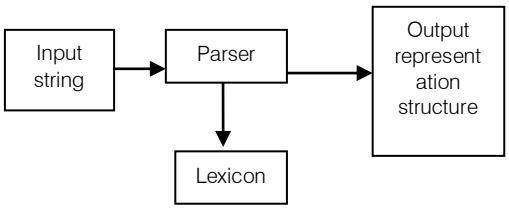


*Fig. 1:* Parsing an input to create an output structure

## II. The Fundamental Architecture of the Proposed Machine Translation (MT) System

The basic architectural block diagram of the proposed MT system is depicted in the following figure. The system works in three steps: lexical analyzing, parsing, and Bengali sentence generation. The Lexical analyzer reads the English sentence, separates the words, and populates it with lexical information. After lexical analysis, all the words of a sentence and the resulting facts are stored into a stack for the parser. The parser uses a rule-based top-down parser to parse the input sentence for syntactic correctness. Finally, the generator produces Bangla Sentence from the parser outputs and the dictionary.

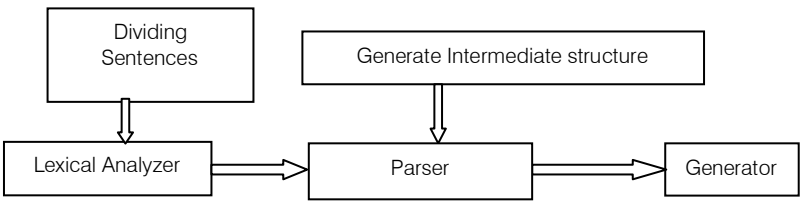


*Fig. 2:* Block diagram of the proposed translator

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*a) Lexical analysis of English contexts*

The Lexical analysis phase of MT is the first step, which is implemented by the Lexical analyzer. It can scan the whole document at a time or one by one. The later strategy is better for parsing, although it is a slow process. Thus sentence scanning and parsing technique have been used in the proposed system. It is looking for the sentence delimiter. It gathers all the information about the words. It tokenizes and sends the information to the parser and subsequently to the generator. During the execution of the Lexical analysis phase, the Lexical analyzer reads the input sentences from the keyboard or a text file given by the user and separates the words. To find the word in the Dictionary, the Lexical analyzer uses the word morphology techniques. For example, in any human language, a word is used in different form, and the dictionary contains only one form. In the lexicon, only the singular form is presented. It can generate its plural by using morphological techniques. The word morphology uses the following strategies:

1. Read the whole word and search it in the dictionary, proceed to the next word if it is found.
2. If dictionary is failed to match the word then check it for the proper noun. If it is proper noun then proceeds for the next word.
3. Discard the last letter from the word and apply the above two steps to the remaining words, if succeeds, check whether the discarded letters are a valid suffix for the recognized word. If it succeeded, it moves to the next word.
4. Repeat steps (iii) each time discarding the one letter from the end of the word until the word is recognized or the length of the word becomes zero, declare the word is not in the dictionary or invalid.

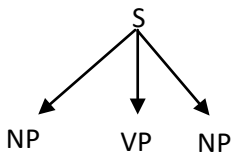
The above procedure considers only the suffix morphology: it can also incorporate prefix morphology for slandering prefixes. For using morphology, it requires to envisage what will be the meaning of the processed word and its part of speech.

*b) Parsing English Sentence (Syntactic Analysis)*

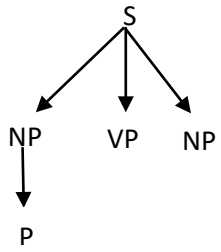
This translator model uses the lexical analyzer. The parser obtains a string of token and verifies the source language which can be generated by the grammar. And one can use any efficient algorithm for parsing. We use top-down parsing technique for this purpose [4]. This parser reports any syntax error in an intelligible fashion. And it should also recover from commonly occurs errors so that it can continue processing of its input. There are two strategies of error recovery, and they are called panic mode and phrase-level recovery. Now the parser knows the format of the English sentence. While parsing, the system determines and keeps some significant information such as number and person of the subject, type of verb, the format of preposition etc. That will be useful during the formation of the Bengali sentence.

i. *Top-Down Parsing*

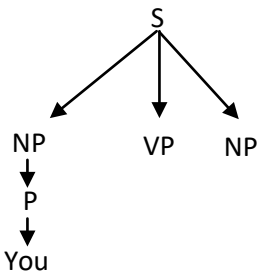
A top-down parser starts by hypothesizing a sentence and gradually predicting lower level element until individual terminal symbols have been written. In other words, top-down parser attempting to find a leftmost derivation for an input string. It trying to build a parse tree from the root of the input and creating the nodes of the parse tree in order. For example, consider the grammar S→NP VP NP, NP→N|P, VP→V, N→Babu | cow |mango, P→You | I | He, V→eat | drink | walk and the input w= I eat mango. A top-down parser is used to construct a parse tree of this sentence, initially creates a tree consisting of a single node labeled S. An input pointer points I, the first symbol of w. Then use the first production of S to expand the tree and obtain



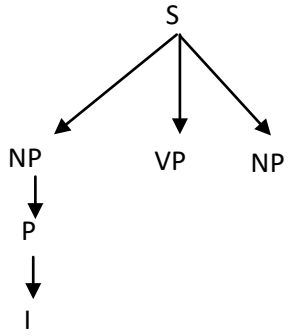

The leftmost symbol of the tree is a nonterminal, so expand it with the production rule for NP and obtain



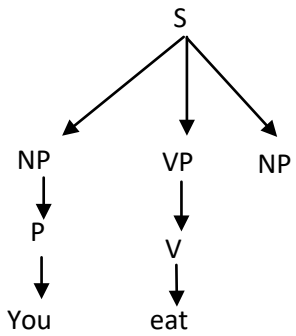

Again, the leftmost symbol is a nonterminal, so expand it with the production rule for P and obtain the following tree.



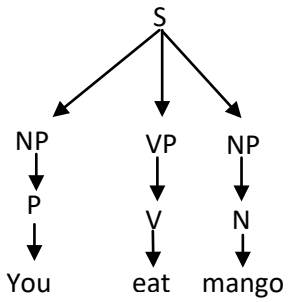

Now the leftmost symbol of the tree is a terminal; compare it with the word pointed by the pointer, which is I and does not match. Then, go back to P and see whether there is another alternate for P, which might produce a match.




Now, using the second alternative of P, replace the terminal you with terminal I, and find a match as shown. Then, forward the pointer to the next symbol of w, eat and go to the next leftmost nonterminal symbol of the tree, which is VP and expand it with its production rule. The last symbol inserted is not a terminal, which is a nonterminal V and expand it using its production rule and obtain following tree representation.




Then, forward the pointer to the next symbol of w, mango and go to the next leftmost nonterminal symbol of the tree, which is NP and expand it with production rule. The last symbol inserted is a nonterminal, so expand this using its production rule and obtain following tree representation.




Now, the last inserted word is a terminal symbol, the pointer reaches at the end of the input sentence w, and complete parsing process.

*c) Intermediate Representation*

After parsing, the system knows the structure of the given English sentence. For each formation of grammars, the system also has the structure in the database that compares the Bengali pattern of the corresponding English structure. With the structure the system now translates the input English sentence into a converted form. It is the intermediate representation of the sentence.

*d) Translating into Bangla*

The next step is to perform the translation. In this phase, the system fetches the Bengali meaning for each token from the dictionary. The Bengali meaning for each noun or pronoun or adjective or adverb is replaced directly. But in the case of preposition and article, artificial intelligence is applied for the appropriate Bangla meaning.

i. *Modification of meaning*

We had to modify the meaning of the words according to different kinds of criterions such as verbs, articles, and prepositions [10]. In this section, we present different modifications to the meaning of the words.

a. Verb

The need for the verb table is due to the differences between the form of the verbs in English and Bengali languages. In English, there are four kinds of forms of each verb, but in Bengali, there are more than twenty-seven kinds of forms for each verb. So it becomes too difficult to find out the appropriate form of Bengali meaning. For this reason, we have to use a reliable method, which can create a direct link between the English and Bengali form of verb. For the present form of verb there are three categories in the meaning of the verb. Those are:

Verb that ends with a meaning "ওয়া"(ooa). Example: Give="দেওয়া"
Verb that ends with a meaning "া"(akar). Example: Do="করা"
Verb that ends with a meaning "নো"(no). Example: Spin="ঘোরানো"

Following table represent different formation of verb:

| Rule | English word | Bangla meaning | 1st person | 2nd person | 3rd person |
|---|---|---|---|---|---|
| "ওয়া"(ooa) changed to "ই"for 1st person ,"ও" for 2nd person and "য়"for the third person. | Give | দেওয়া | দেই | দেও | দেয় |
| "া"(akar) changed to "ই"for 1st person , "ও" for 2nd person and "এ"for the third person. | Do | করা | করি | করো | করে |
| "নো"(no) changed to "ই"for 1st person ,"ও" for 2nd person and "য়"for the third person. | Spin | ঘোরানো | ঘোরাই | ঘোরাও | ঘোরায় |

b. Preposition

A preposition is a word placed before a pronoun or noun-equivalent to show its relation to any other word of the sentence. The noun or pronoun or the noun equivalent is called its object.

## III. Designing the Database

Our first job for any language conversion is to design and build a database to work as a dictionary. For that, we first determine the properties of any word which are required to understand the use of it in any kind of sentence. We needed a primary key column that contains the characteristics if any word which will be unique. And that required property is the word itself. And now we need a few columns to store various meanings of the word; the maximum meaning can occur to only verbs. Verbs have various meanings for the different person of the subject. They may also have special meanings that are required after modals or as gerunds. So we created four columns to hold those meanings and took two columns for containing their parts of speech and their type. We also create a column named person to store the person of word if it is used as a subject. We also created two columns for holding the antonyms and synonyms of the word. And then, we inserted the words and their properties in the table. We use MySql Query Browser to perform those actions.

*a) Returning a required property of a word*

We create a function named 'find' to return particular properties of certain words. While calling that function, we passed a string and two integers as parameters. The string contains the word to match with the dictionary. First integer specifies from which column we search the word to match. The other integer specifies contexts of which column will return to function. A different column holds different properties like meanings, parts of speech etc, of the word.

*b) User input to the Database*

While translating, we may find a word that doesn't exist in our dictionary. In that case, we ask the user to give the meaning and other properties of the function. We simply call another window page to take the input and have passed the inputs into the 'insert' function. The insert function takes the properties as parameters, builds a query statement, and then calls 'execute update' function passing that statement as a parameter. The function executes that query and inserts the properties.

## IV. Algorithm

Here we will see the general procedure of our translation task.

Algo_Translation()

*Step-1:* Take and input English sentence from the user.

*Step-2:* Split the sentence into word.

*Step-3:* For each word do step 4

*Step-4:* From dictionary find the appropriate meaning, parts of speech, type(whether the subject, object or none), person (if subject or object)

*Step-5:* From above, find the subject, the verb, and the object of the sentence.

*Step-6:* Determine the structure of the sentence by the placement of subject, object, verb, person of subject etc.

*Step-7:* Put the word meanings as an order by which a corresponding Bangla Structure of the English Sentence Formed.

*Step-8:* Show the Bangla sentence at the user interface in any Bangla font}

## V. Translating the Sentence to Bangla

Dividing Our work into following parts

1. Pre-processing the sentence.
   i. Dividing the sentence into words
   ii. Checking if any word doesn't exist in the Dictionary
   iii. Setting and saving parts of speech and types of words.
2. Finding the primary subject of the sentence.
3. Determining the type of sentence.
4. Putting the appropriate meaning in order.

*a) Pre-processing of the sentence before actual translating*

We divide the sentence using the split function and store the words in a string array. Then calling the 'find' function for each word we first see whether it exist in the dictionary or they are some processed form of a word that exists in the dictionary. We pass the word to a function named 'match' to check some modified form of an existing word (such as eats is a modified form of eat). By using this function we re-modify the word and match it with an existing word. If it exists then we get and save their parts of speech in 'POS' array of strings again with the help of 'find' function and save their types (whether it can be used as subject or object or both or none) in 'TYPES' array of string.

i. *Finding the Subject*

The most vital job to translate is to find the subject of the sentence. The form of verb varies with the person of subject, and positioning of words depends on it. So we create and use the function 'find Sub' for finding the subject. In that function, we check the previously construct 'Types' array. In a sentence, the subject is the first encountered word, which is either a noun or a pronoun or a gerund. So we search the Types array for the first word whose type is either 'subject' or 'both' until the occurrence of a verb or the end of sentence and place the meaning of the subject in a sentence. If we find an adjective before the occurrence of the subject then we place that before the subject. If we do not trace a subject then we assume the sentence as an imperative one, and the person of the subject is assigned. After finding the subject, we return from the function. Though we will return from the function if we find a verb assuming the sentence as imperative, however, we will continue even if we find auxiliary verb or a modal verb, but we will stop if we find 'let'. We also set the Boolean variable to have modal as true if we find a modal. We also set the Boolean used[i] as true where i+1 is the position of the subject or Auxiliary verb.

ii. *Setting the type of sentence*

Now one of our important jobs is to determine the type of sentence. We have divided it according to its meaning. We determine whether this is assertive, interrogative, imperative, optative, or exclamatory. We initially assume the sentence type as an assertive one. However, if the first word is a modal one but not 'let' or is an auxiliary verb or 'wh' pronoun, then sets the type as an interrogative sentence and calls the created function 'SetAs Question'. If it finds a verb as the first word, then it sets type as imperative. If the first word is 'may', then it is an optative one. Otherwise, we stick to our initial guess as assertive. If the first word is a modal, then the type is also modal, and then we set Boolean has modal as true. The function determines the questioning word, when the function 'setAsQuestion' is called. If the first word is 'wh' type, then the questioning word is the corresponding meaning. Otherwise the questioning word is the meaning of 'what' ("ki"). After determining the questioning word, we place that word after the subject.

iii. *Putting the Bangla meaning together*

Now we have done all the requirements of understanding the forms and meaning of a sentence. Now we will put the appropriate meanings in the sentence and thus will be building our translated sentence. For this, first, we use a for-loop to consider all the words in the given sentence. If the considering word is a preposition, then we will retrieve the corresponding meaning from the second column of the table dictionary from the database. Then we hold the meaning in a stack as it will use later after the object. If we find an "Adjective", then that will also be held in a stack. If we trace a word of type "negation", then we check if the previous word was an auxiliary verb or modal or do, does, did. If so, then we understand that the sentence is a negative one. When the type is negative, then we place the meaning of that word in the string "AfterVerb". If we find a verb, then we call function 'placeverb' and 'placeobject'. If we find a word, it can be used as an object. And if we find an auxiliary verb, we neglect that and move to the next word. And in any other case, we put the word straight into the sentence.

*b) Process of getting output*

Let the input sentence is, "I am eating mango and he is drinking milk." At first, the sentence is broken into two sentences, and those are:

1. "I am eating mango."
2. "He is drinking water."

Then the system takes the first sentence for processing. The sentence is read from left to right and grouped into words that are separated by space. Function split() is used to do this. The output of this function is a sequence of words constituting the sentence:

1. I
2. Am
3. Eating
4. Mango

Then we search each word in the dictionary and obtain its parts of speech and its meaning. We rearrange words of the sentence by using the rules of part of speech. Here we have the following English structure:

Pronoun + Aux + Verb +Noun ( I am eating mango)

We get following sentence structure after re-arranging it.

Pronoun + Noun + Verb (I mango eating)

After this step, the words are arranged as

1. I
2. Mango
3. Eating

Now an intermediate representation is constructed by direct word–to- word interpretation. After this step, we have intermediate Bangla representation:

আমি আম খাচ্ছি

Now the meaning of "eating", i.e. "খাচ্ছি" is modified according to the person of the subject (1st person in this case) and tense (continuous in this case).

After all other necessary modifications, the meaning of the sentence is "আমি আম খাচ্ছি" . It is the output of the translator. Other part of the sentence is "he is drinking water", which follow the same process. After this, the conjunction meaning picked from the database and places it between two parts of the sentence. Finally, we will see the following output.

আমি আম খাচ্ছি এবং সে পানি খাচ্ছে

## VI. Some Experimental Result

| Input sentence (in English) | Translated Sentence (in Bangla) |
|---|---|
| It is his luck | এটা তার ভাগ্য। |
| It is a wrong word. | এটা একটি ভুল শব্দ। |
| The market is noisy | বাজারটি কোলাহলময় |
| Let me go. | আমাকে যেতে দাও। |
| Let him go. | তাকে যেতে দাও। |
| See the sky. | আকাশটি দেখ। |
| Read the book. | বইটি পড়। |
| Am I eating? | আমি কি খাচ্ছি? |
| Is he eating? | সে কি খাচ্ছে? |
| Do I eat rice? | আমি কি ভাত খাই? |
| Does he go to school? | সে কি স্কুলে যায়? |
| How are you? | তুমি কেমন আছো? |
| May I go? | আমি কি যেতে পারি? |
| When will you go? | তুমি কখন যাবে? |
| Which book do you like? | তুমি কোন বই পছন্দ কর? |
| We are enjoying song. | আমরা গান উপভোগ করছি। |
| This is my country. | এই আমার দেশ। |
| Shall I go? | আমি কি যাব? |
| You will drink milk. | তুমি দুধ পান করবে। |
| Walking is good. | হাটা ভালো। |
| I have asked him. | আমি তাকে জিজ্ঞাসা করেছিলাম। |
| He has added it. | সে এটা যোগ করেছিলো। |
| The sky is blue. | আকাশ নীল। |
| Reading book is good. | বই পড়া ভালো। |
| I run fast. | আমি দৌড়াই। |
| I drink milk and you see fish | আমি দুধ পান করি এবং তুমি মাছ দেখ। |
| I am weak but he is strong. | আমি দুর্বল কিন্তু সে শক্তিশালী। |

## VII. Discussion

The user can be able to append the required word and its necessary information in the dictionary. Suppose, the input sentence of our system is "Bangladesh is a beautiful country." And our dictionary does not contain the word "beautiful". So, for this input, the system responds with the message as follows:

"দুঃখিত, আপনার দেওয়া কোন একটি শব্দ অভিধানে নাই"

The user can eliminate this problem by adding the bangla meaning of the word "beautiful" to the dictionary, and then we get the following output

" বাংলাদেশ একটি সুন্দর দেশ "

In the case of a syntactically correct sentence, the system translates nicely. However, when a sentence

is syntactically incorrect, or the delimiter of the sentence does not match the sentence type, the system tries to find the nearest match and translate and finally gives the closest Bangla output. This system can translate an assertive, interrogative, optative, imperative, exclamatory, simple, compound, and complex sentences. There are more sophisticated compound sentences, which may contain more than one clause. The system cannot provide any output for this type of sentences. We can solve this problem by adding rules for parsing multi-casual sentence. This system can translate both active voiced and passive voiced sentences. Besides this, the morphological techniques of English and Bangla are implemented in the scanning and generation phases, respectively. But Bangla sentence has several construction rules for personal pronouns. So, this system does not support all of them. This system supports one form only. For example, consider the translation of the sentence, "You are a good girl.". The translation may be "**তুমি একজন ভাল মেয়ে।**" or "**তুই একজন ভাল মেয়ে।**" etc. However, the system gives only "**তুমি একজন ভাল মেয়ে।**" as output. The word "You" has several meanings, and it is difficult to translate it in the correct form in the context of Bangla grammar. Similarly, the meaning of "He" or "She" may be **সে** or **তিনি.** This type of problem is common in Bangla grammar. So, it is difficult to construct a Machine Translator for Bangla to handle all possible meaning of a word. In English language, the same word can be used as different parts of speech in different sentences. As a result, identify the correct form of a particular word in a sentence is a difficult task.

In most cases, the preposition does not maintain specific rules in English sentences. Therefore, it is difficult for a rule-based parser to correctly identify prepositions for a particular meaning. For example, "to" is a preposition and it can be used as-

1. "I run quickly to the large house". Here "to" is used to represent Bangla suffix "দিকে"
2. "I have no money to buy a car". Here "to" is used to represent Bangla suffix "মতো"
3. "He goes to school". Here "to" is used to represent Bangla suffix "দিকে"

There is no precise grammar in English for determining cases of nouns and pronouns. But it is an essential tool in Bangla to express something clearly. Therefore, cases of different nouns and pronouns in an English sentence should be identified properly before translating a sentence into Bangla. Here, detecting the relative position of the noun and pronoun with the verb and other words in English.

On the other hand, In Bangla, they are identified by considering the suffixes with nouns and pronouns.

Bangla is a relatively free word order language than English. So, sentence construction in Bangla has a less specific rules. For example, let us consider the sentence "You have given him pen". This sentence can be translated as

1. "তুমি তাকে কলম দিয়েছ"
2. "তাকে তুমি কলম দিয়েছ"
3. "তুমি কলম দিয়েছ তাকে"
4. "তাকে কলম দিয়েছ তুমি"

Therefore, for Bangla sentences, parser design is very difficult. More complicated grammar should be developed to avoid the problem.

## VIII. Conclusion

The system provides the user with the facility to append new words in the dictionary. Though the number of the given words is a subset of the English language. The user can enrich the stock of words with the help of an expert who has sufficient knowledge in both english and bangla language. Although the developed system is successful in many aspects, Still have some limitations those are:

1. The knowledge base in this system is not self-learning. It cannot interfere the existing decision in the knowledge base.
2. The system cannot handle the contextual and semantic problems.

## Reference and Bibliography


1. M. Haque and M. Hasan, "English to Bengali Machine Translation: An Analysis of Semantically Appropriate Verbs," 2018 International Conference on Innovations in Science, Engineering and Technology (ICISET), Chittagong, Bangladesh, 2018, pp. 217-221.
2. Nur Hossain Khan, Md. Farukuzzaman Khan, Md. Mojahidul Islam, Md. Habibur Rahman, Bappa Sarker, Verification of Bangla Sentence Structure using N-Gram, Global Journal of Computer Science and Technology: A Hardware & Computation Volume 14 Issue 1 Version 1.0 Year 2014
3. M. K. Rhaman and N. Tarannum, "A Rule Based Approach for Implementation of Bangla to English Translation," 2012 International Conference on Advanced Computer Science Applications and Technologies (ACSAT), Kuala Lumpur, 2012, pp. 13-18.
4. Md. Musfique Anwar, Mohammad Zabed Anwar and Md. Al-Amin Bhuiyan, Syntax Analysis and Machine Translation of Bangla Sentences, IJCSNS International Journal of Computer Science and Network Security, VOL.9 No.8, August 2009.

5. A. P. Mukta, A. Mamun, C. Basak, S. Nahar and M. F. H. Arif, "A Phrase-Based Machine Translation from English to Bangla Using Rule-Based Approach," 2019 International Conference on Electrical, Computer and Communication Engineering (ECCE), Cox's Bazar, Bangladesh, 2019, pp. 1-5.
6. Md. Shahidur Rahman," Bangali Sorting Algorithm :A Linguistic Approach ", NCCPB ,2004.
7. Md. Abdul Muttalib," A Review on Computer Based Bangali Processing ", NCCPB ,2004
8. P .C. Wren & Martin," English Grammar & Composition", & Company LTD, 2000 .
9. Lelin Mehedy, S. M. Niaz. Arifin, M .Kaykobad," Bangali Syntax Analysis: A Comprehensive Approach ", ICCIT, 2003.
10. Masud, M .A .N Jorder, M. M. Tariq-Ul-Azam," A Case Study on Syntactic Approach to Natural Language Processing", Undergraduate Thesis Paper, Computer Science And Engineering Discipline, Khulna University, Bangladesh November 2001 .
11. Aho, A.V. Shethi, R, Ulman, J.D. "Compiler Principle Techniques and Tools", Pearson Education Sixth Indian Reprint, 2001.
12. Chowdhury, Z.A., "Modern Applied Grammar Translation Composition", Globe Library (PVT.) Limited Edition 1997.
13. Ahmed E. "English Grammar and Translation", Globe Library, 1989.
14. M.D., Rahman, S.H., Vchchotor Bangali Grammar", Globe Library, 1989.

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# Palestine Radar Model (PRM) for Predicting the Number of Infected Cases of COVID-19 Virus in Palestine

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*Abstract-* In the light of the COVID-19 virus pandemic that has attacked the earth planet, all nations in the world are becoming suffered more and more from the increasing number of infected cases. The medical infrastructure in most countries aren't fit to deal with such pandemic, hospitals in these countries are unable to accommodate a such number of the infected cases that have recently been recorded [1], [5]. This pandemic has put countries in a great predicament; they never expected to face a pandemic of this size [1], [5]. Palestine is one of these pandemic victims, COVID-19 virus has started spreading in Palestine on fifth March of 2020 [4]. Palestinian government and leadership have announced immediately by its Prime Minister Dr Mohammad Shtayyeh the case of emergency in Palestine to prevent this dangerous pandemic from spreading, by closing all schools and universities, crowding prevention, limiting motion and asking people strongly for home-stay [1], [2], [4].

*Keywords:* *COVID-19 pandemic, palestine radar model, PRM, linear prediction, forecast function.*

*GJCST-G Classification:* *D.4.8*


*Strictly as per the compliance and regulations of:*

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*Keywords: COVID-19 pandemic, palestine radar model, PRM, linear prediction, forecast function.*

## I. Introduction

Palestine Radar Model (PRM) for predicting the number of infected cases of COVID-19 virus is a computerized model that can predict the number of the infected cases of COVID-19 virus in Palestine for any date starting from (1) April of 2020. This model is designed by using the Microsoft Office Excel program. The results will be obtained directly after running the model; these results can help the Palestinian government, leadership and people with the expected development related to the expected number of infected cases of the COVID-19 virus in the coming days.

This study shows the expected number of the infected cases of COVID-19 virus in Palestine for the coming April month. The results are recorded, and they can put the Palestinian government, leadership and people in the light of the expected future.

## II. A Mission & Benefits of Palestine Radar Model

Palestine Radar Model (PRM) can help Palestine towards stopping the spread of COVID-19 virus by giving the expected numbers of future infected cases, as follows:

*Firstly, For Palestine government and leadership:*

Knowing the expected number of the future infected cases of COVID-19, will help the Palestine government and leadership how to manage the pandemic awesomely and with minimum loss by making suitable decisions and actions, especially that Palestine government has preferred using the prevention strategy that is based on (social spacing theory) before using the treatment strategy [2],[4]. These decisions and actions may include the following:

a) Continuing on emergency case with its all directions in Palestine lands.
b) Developing a more hard emergency case.
c) Continuing on people and society culture rising towards stopping the spread of COVID-19 virus in Palestine.
d) Ensuring the power of Palestine medical infrastructure for facing the coming future.

*Secondly, For Palestine People and Society:*

By applying the previous actions and decisions from the Palestine government and leadership, the safety of people and society will be increased as far as the more commitment and discipline from them.

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## III. Study Methodology

This study is theoretical and experimental research; it uses the linear prediction technique in the Microsoft Office Excel program by using the (Forecast Function) that is included in the statistical category of Microsoft Office Excel program library [9],[11].

In the Microsoft Office Excel Program, there are two familiar methods to implement the linear prediction, which are [9],[11],[12]:

*a) Using the (Forecast) statistical function*

Here, the linear prediction will be implemented directly. Since the (Forecast) statistical function is readily available in the Microsoft Office Excel program library. It can be used directly when all historical data are enough and ready.

*b) Using the regression line equation*

Here, the linear prediction will be implemented after finding the regression line equation, which is:

$$Y = a.X + b \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad eqn\ (1)$$

Where:

Y: The dependent variable. a: Regression coefficient.

X: The independent variable. b: The constant parameter.

So, the implementing of the linear predication in this method requires the following procedure:

*Firstly,* the finding of both parameters: the regression coefficient (a) and the constant (b) as follows:

The regression coefficient (a) can be obtained directly by using (Slope Function) that is included in the statistical category of Microsoft Office Excel program library. Also, the constant (b) can be obtained directly by using (Intercept Function) that is included in the statistical category of Microsoft Office Excel program library.

*Secondly,* writing the previous regression line equation.

*Thirdly,* divide all historical data to be either independent variables or dependent variables and determine them.

Now, the prediction of the (Y) value can be obtained when the corresponding(X) value is entered.

This study uses the forecast statistical function method to implement the linear prediction, which will increase the efficiency of the study model, since it will save time and effort in using this model, by avoiding the use of regression line equation in the Microsoft Office Excel program which requires more time and effort due to its long procedure.

## IV. How Does the Model Work?

The Palestine Radar Model (PRM) uses the linear predication by using the (Forecast Function) that is categorized under Excel statistical functions. It will calculate and predict future values using existing historical values.

The Palestine Radar Model (PRM) uses the previous numbers of infected cases of COVID-19 with their dates in Palestine starting from the beginning of the (5th March 2020) to the end of (31th March 2020), as its historical data[3],[4].

The sequential numbers of the dates are used as independent variables (X Values), and the numbers of the infected cases corresponding to these dates, as dependent variables (Y Values).

Now, (PRM) can predict the future values of the infected cases of COVID-19 virus for future dates, by entering the corresponding numbers of these dates. The results will appear immediately. The following figure shows the (PRM):

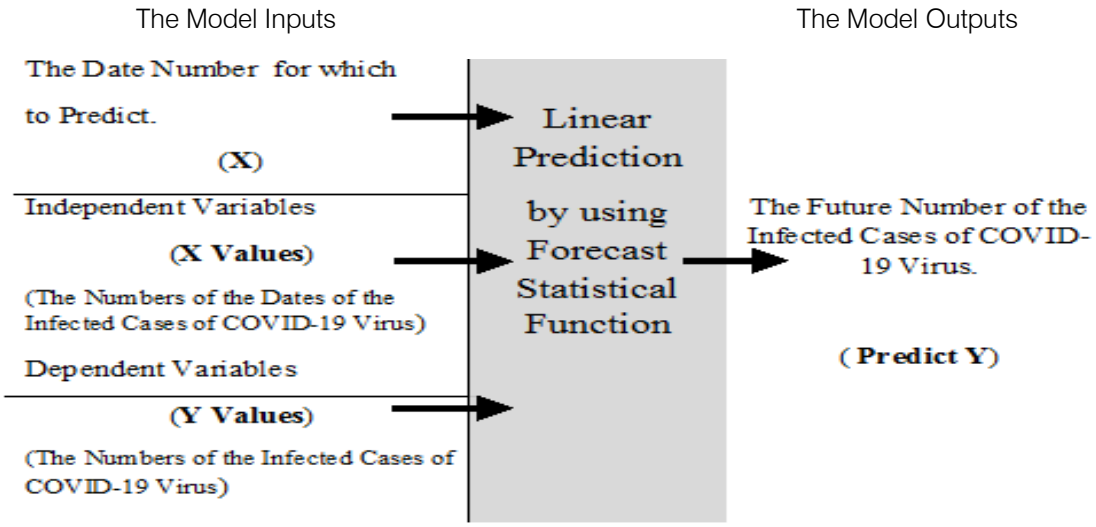


*Figure 1:* The Palestine Radar Model (PRM)

## V. Results Accuracy

The accuracy of the model results which are the expected numbers of the infected cases of COVID-19 virus in Palestine for the coming dates depends on the accuracy of input data of the model.

The input data of the model which are the historical numbers of the infected cases from the beginning of the (5th March 2020) to the end of (31th March 2020) and their corresponding dates are being recorded accurately according to the daily reports of the Palestine Ministry of Health [4].

So, this study expects accurate results with a surely normal percentage of error which comes from prediction.

## VI. Designing the Model

The Palestine Radar Model (PRM) is designed by using Microsoft Office Excel Program. The model includes two main sections, as follows:

The first section is the (Input Section) which includes the following parameters:

a) The historical dates from the beginning of the (5th March 2020) to the end of (31th March 2020).
b) The corresponding sequential numbers of the previous dates.
c) The historical numbers of the infected cases from the beginning of the (5th March 2020) to the end of (31th March 2020).

*The following figure shows the input section of the model design [1], [2], [4]:*

| | A | B | C |
|---|---|---|---|
| 1 | Palestine Radar Model for Predicting the Number of Infected Cases of COVID-19 Virus | | |
| 2 | | | |
| 3 | The Date | Number | The Number of Infected Cases of COVID-19 Virus |
| 4 | 5/3/2020 | 1 | 7 |
| 5 | 6/3/2020 | 2 | 7 |
| 6 | 7/3/2020 | 3 | 16 |
| 7 | 8/3/2020 | 4 | 19 |
| 8 | 9/3/2020 | 5 | 27 |
| 9 | 10/3/2020 | 6 | 27 |
| 10 | 11/3/2020 | 7 | 30 |
| 11 | 12/3/2020 | 8 | 31 |
| 12 | 13/3/2020 | 9 | 35 |
| 13 | 14/3/2020 | 10 | 38 |
| 14 | 15/3/2020 | 11 | 38 |
| 15 | 16/3/2020 | 12 | 39 |
| 16 | 17/3/2020 | 13 | 41 |
| 17 | 18/3/2020 | 14 | 44 |
| 18 | 19/3/2020 | 15 | 47 |
| 19 | 20/3/2020 | 16 | 48 |
| 20 | 21/3/2020 | 17 | 52 |
| 21 | 22/3/2020 | 18 | 59 |
| 22 | 23/3/2020 | 19 | 59 |
| 23 | 24/3/2020 | 20 | 60 |
| 24 | 25/3/2020 | 21 | 62 |
| 25 | 26/3/2020 | 22 | 86 |
| 26 | 27/3/2020 | 23 | 91 |
| 27 | 28/3/2020 | 24 | 97 |
| 28 | 29/3/2020 | 25 | 108 |
| 29 | 30/3/2020 | 26 | 116 |
| 30 | 31/3/2020 | 27 | 117 |



*Figure 2:* The First Section of the Model Design

The second section is the (Output Section) which includes the expected numbers of the infected cases of COVID-19 virus in Palestine for future dates.

The study uses the model for predicting the infected cases of COVID-19 virus in Palestine for coming April month, specifically in the following dates: (4/4/2020, 12/4/2020, 19/4/2020, 30/4/2020)

*The following figure shows the output section of the model design:*

| | A | B | C |
|---|---|---|---|
| 32 | ( The Predicting Results for the Coming April Month ) | | |
| 33 | The Date | The Number of Predected Infected Cases of COVID-19 Virus | |
| 34 | 4/4/2020 | | |
| 35 | | (??) Predected Infected Cases | |
| 36 | 12/4/2020 | | |
| 37 | | (??) Predected Infected Cases | |
| 38 | 19/4/2020 | | |
| 39 | | (??) Predected Infected Cases | |
| 40 | 30/4/2020 | | |
| 41 | | (??) Predected Infected Cases | |
| 42 | | | |
| 43 | (GOD Save our Home) | | |
| 44 | | | |

*Figure 3:* The Second Section of the Model Design

Now, at each previous date, the study will use the Forecast statistical function, to find the predict number of the infected cases of COVID-19 in Palestine.

## VII. Operating the Model

At each previous date to predict (4/4/2020, 12/4/2020, 19/4/2020, 30/4/2020), the study will use the Forecast statistical function, to find the predict number of the infected cases of COVID-19 in Palestine. The Excel window of the Forecast statistical function is as follows:

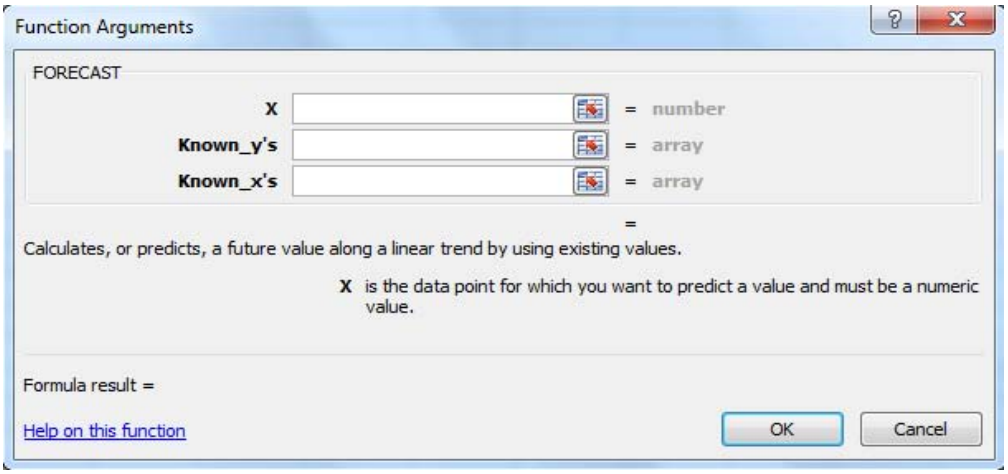


*Figure 4:* The Forecast Statistical Function Window

The entered data on the previous figure (4), are as follows:

X: The sequential number of the date for which to predict.

Y's: The numbers of the infected cases of the COVID-19 virus, which are the model- dependent variables.

X's: The sequential numbers of the dates of the infected cases of the COVID-19 virus, which are the model-independent variables.

Now, for the dates that the model looking to predict for them, the entered data of the Forecast function will be as follows:

*Table 1:* The Entered Data of the Forecast Function

| Dates to Predict | X | Y's | X's |
|---|---|---|---|
| 4/4/2020 | 31 | C4:C30 | B4:B30 |
| 12/4/2020 | 39 | C4:C30 | B4:B30 |
| 19/4/2020 | 46 | C4:C30 | B4:B30 |
| 30/4/2020 | 57 | C4:C30 | B4:B30 |

## VIII. The Results

After running the model, the results that are related to the expected numbers of the infected cases of COVID-19 virus in Palestine are as follows:

| | A | B | C |
|---|---|---|---|
| 32 | ( The Predicting Results for the Coming April Month ) | | |
| 33 | The Date | The Number of Predected Infected Cases of COVID-19 Virus | |
| 34 | 4/4/2020 | 116.7130647 | |
| 35 | | (117) Predected Infected Cases | |
| 36 | 12/4/2020 | 147.2185592 | |
| 37 | | (147) Predected Infected Cases | |
| 38 | 19/4/2020 | 173.9108669 | |
| 39 | | (174) Predected Infected Cases | |
| 40 | 30/4/2020 | 215.8559219 | |
| 41 | | (216) Predected Infected Cases | |
| 42 | | | |
| 43 | (GOD Save our Home) | | |
| 44 | | | |

*Figure 5:* The Results

## IX. Results Analysis

According to the model results which are shown in the previous figure (5), there is a negative side and also a positive side, as follows:

*a) The Negative Side of the Results*

As it is shown to the results in the figure (5), there is an increase for the expected numbers of the infected cases of COVID-19 virus in Palestine during the coming April. The expected number of the infected cases of COVID-19 virus in Palestine till to the end of 30th April 2020 is expected to reach to (216) infected case.

*b) The Positive Side of the Results*

As it is shown in whole study, from the beginning of 5th March 2020 to the end of 30th April 2020, there is a decrease for the (Growth Rate) of spreading the COVID-19 virus in Palestine by more than (15%).

i. *Finding the (Growth Rate) of the Study*

a. The historical data of the number of infected cases of COVID-19 virus in Palestine from the beginning of (5th March 2020) to the end of (31th March 2020) is: (117) infected cases.
So, in (26) days of past March 2020, the number of infected cases is: (117).

b. The predicted data of the number of infected cases of COVID-19 virus in Palestine from the beginning (4th April 2020) to the end of (30th April 2020) is: (216 – 117) = (99) infected cases.

So, in (26) days of the coming April 2020, the number of infected cases is: (70).

So, previous calculations are concluded in the following table:

*Table 2:* The Comparison between Historical and Predicted Data

| *Historical Data* | | *Predicted Data* |
|---|---|---|
| Number of Days | *26* | *26* |
| Number of Infected Cases | 117 | 99 |

Now,

$$Growth\ Rate = (\text{Present} - \text{Past})/\text{Past} \ldots\ldots eqn\ (3)\ [9].$$

Therefore, the Growth Rate of spreading COVID-19 virus in Palestine is implemented by the following mathematical equation:

$$\frac{\text{Predicted Number of Infected Cases} - \text{Historical Number of Infected Cases}}{\text{Historical Number of Infected Cases}} \ldots\ldots eqn\ (4)$$

$$= (99 - 117)/117 = (-0.1538)$$

And this means that the Growth Rate of spreading COVID-19 virus in Palestine for the coming (4) weeks will decrease by more than (15%).

## X. Conclusion and Recommendations

*a) Conclusion*

Palestine Radar Model (RPM) predicts the spreading of COVID-19 virus in Palestine for the coming

April 2020 that is ended in the following dates respectively: (4/4/2020, 12/4/2020, 19/4/2020, 30/4/2020), with two contradictory results as follows:

*The bad results:* there is an increase in the expected numbers of the infected cases of COVID-19 virus in Palestine during the coming April 2020. The expected number of the infected cases of COVID-19 virus in Palestine till to the end of 30th April 2020 is expected to reach to (216) infected case.

*The good results:* there is a decrease for the (Growth Rate) of spreading the COVID-19 virus in Palestine by more than (15%) till to the end of 30th April 2020. The study refers that for the awesome emergency case that the Palestinian government and leadership have applied on Palestine, which adopts the preventing strategy before treatment strategy, by applying the theory of social spacing through closing the schools and universities, limiting motion, asking people strongly for home-stay, Isolating the cities and towns, stopping the tourism activities, and closing the borders. In addition to the ongoing awareness activities for people and society about COVID-19 virus through the various media and also and the social media.

*b) Recommendations*

This study presents the following recommendations for Palestinian government and leadership and also for the society and people:

- The study strongly asks from the Palestinian government and leadership to continue in applying the case of emergency in Palestine for the coming April 2020.
- Ensuring from the ready of Palestine medical infrastructure to deal with the expected numbers of infected cases that this study predicts for the coming April 2020, especially, that the expected number of infected cases that is predicted by the study model is: (216) infected cases.
- Activate and develop more awareness activities about preventing COVID-19 virus for society and people from the specialized sides of the government, especially after the success of the emergency case that has launched by Palestine government which may reduce the growth rate of spreading the COVID-19 virus by more than (15%) according to the results of this study, and which means the receding of the virus instead of the spreading it more.
- The development of the emergency case to be stronger is better.
- Asking society and people for more commitment towards Palestine leadership instructions and advises.

*-Asking God to Save our Home-*

## References Références Referencias


1. https://www.who.int/
2. http://www.palestinecabinet.gov.ps/
3. http://www.corona.ps/
4. http://site.moh.ps/
5. https://ar.wikipedia.org
6. Burity, Vítor. (2020). COVID-19.
7. Piri, Farideh. (2020). covid 19.
8. Hill, Catherine. (2020). covid-19.
9. Abu Omar, Dr. Mohammad. (2016). An Effective Model to Design the Management Information Systems (MIS). Scholars Press ISBN:978-3-659-84065-4
10. M. M. Abu Omar, "A New Approach to Increase the Efficiency of Classical Approach In Designing Management Information Systems (MIS'S)," IJRCCT, vol. 3, pp. 1421-1424, 2014.
11. M. M. Abu Omar, "Developing New Methods in designing Management Information Systems to solve Management Problems by using Classical Approach," International Journal of Computer Applications, vol. 101, 2014.
12. M. M. A. Omar and K. A. Abdullah, "Testing the Use of the Integrated Model in Designing the Management Information Systems by Using the Mathematical Probability Theories," International Journal of Advanced Computer Science & Applications, vol. 1, pp. 159-165, 2015.
13. M. M. A. Omar and K. A. Abdullah, "Developing a New Integrated Model to improve the using of Classical Approach in Designing Management Information Systems," International Journal of Advanced Computer Science & Applications, vol. 1, pp. 190-197, 2015.
14. M. M. A. Omar and K. A. Abdullah, "USING OF NET PRESENT VALUE (NPV) TO TEST THE INTEGRATED MODEL IN BUILDING MANAGEMENT INFORMATION SYSTEMS," Journal of Economics Finance and Accounting, vol. 3, 2016.
15. Stuerzlinger, Wolfgang & Zaman, Loutfouz & Pavlovych, Andriy & Oh, Ji-Young. (2006). The design and realization of CoViD: A system for collaborative virtual 3D design. Virtual Reality. 10. 135-147. 10.1007/s10055-006-0048-0.

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g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

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***1. Choosing the topic:*** In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

***2. Think like evaluators:*** If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

***3. Ask your guides:*** If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

***4. Use of computer is recommended:*** As you are doing research in the field of computer science then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

***5. Use the internet for help:*** An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

***6. Bookmarks are useful:*** When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

***7. Revise what you wrote:*** When you write anything, always read it, summarize it, and then finalize it.

***8. Make every effort:*** Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

***9. Produce good diagrams of your own:*** Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

***10.Use proper verb tense:*** Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

***11. Pick a good study spot:*** Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

***12. Know what you know:*** Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

***13. Use good grammar:*** Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

***14. Arrangement of information:*** Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

***15. Never start at the last minute:*** Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

***16. Multitasking in research is not good:*** Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

***17. Never copy others' work:*** Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

***18. Go to seminars:*** Attend seminars if the topic is relevant to your research area. Utilize all your resources.

***19. Refresh your mind after intervals:*** Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

***20. Think technically:*** Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

***21. Adding unnecessary information:*** Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

***22. Report concluded results:*** Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

***23. Upon conclusion:*** Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

## Informal Guidelines of Research Paper Writing

***Key points to remember:***

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

**Final points:**

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

*The introduction:* This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

**The discussion section:**

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

**General style:**

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

**To make a paper clear:** Adhere to recommended page limits.

*Mistakes to avoid:*

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

**Title page:**

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

**Abstract:** This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

*Reason for writing the article—theory, overall issue, purpose.*

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

**Approach:**

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

**Introduction:**

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

*The following approach can create a valuable beginning:*

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

**Approach:**

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

**Procedures (methods and materials):**

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

**Materials:**

*Materials may be reported in part of a section or else they may be recognized along with your measures.*

**Methods:**

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

**Approach:**

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

**What to keep away from:**

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

**Results:**

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

**Content:**

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

**What to stay away from:**

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

**Approach:**

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

**Figures and tables:**

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

**Discussion:**

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

**Approach:**

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

## The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

*Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection*.

*Segment draft and final research paper:* You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

*Written material:* You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

## Criterion for Grading a Research Paper (Compilation) by Global Journals Inc. (US)

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| Topics | Grades | | |
|---|---|---|---|
| | **A-B** | **C-D** | **E-F** |
| ***Abstract*** | Clear and concise with appropriate content, Correct format. 200 words or below | Unclear summary and no specific data, Incorrect form<br><br>Above 200 words | No specific data with ambiguous information<br><br>Above 250 words |
| ***Introduction*** | Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited | Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter | Out of place depth and content, hazy format |
| ***Methods and Procedures*** | Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads | Difficult to comprehend with embarrassed text, too much explanation but completed | Incorrect and unorganized structure with hazy meaning |
| ***Result*** | Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake | Complete and embarrassed text, difficult to comprehend | Irregular format with wrong facts and figures |
| ***Discussion*** | Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited | Wordy, unclear conclusion, spurious | Conclusion is not cited, unorganized, difficult to comprehend |
| ***References*** | Complete and correct format, well organized | Beside the point, Incomplete | Wrong format and structuring |

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