Innovation Value Chain and Research Opportunities in Systematic Innovation

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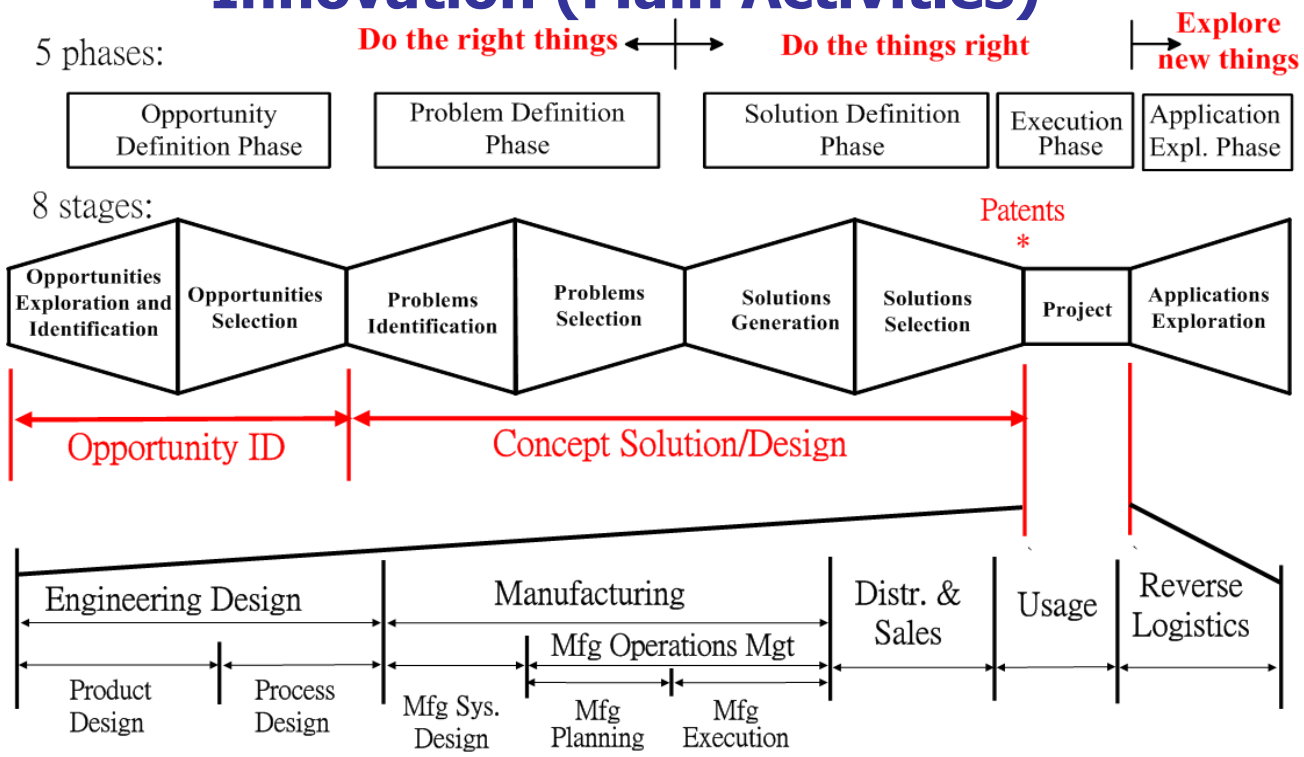
Outline

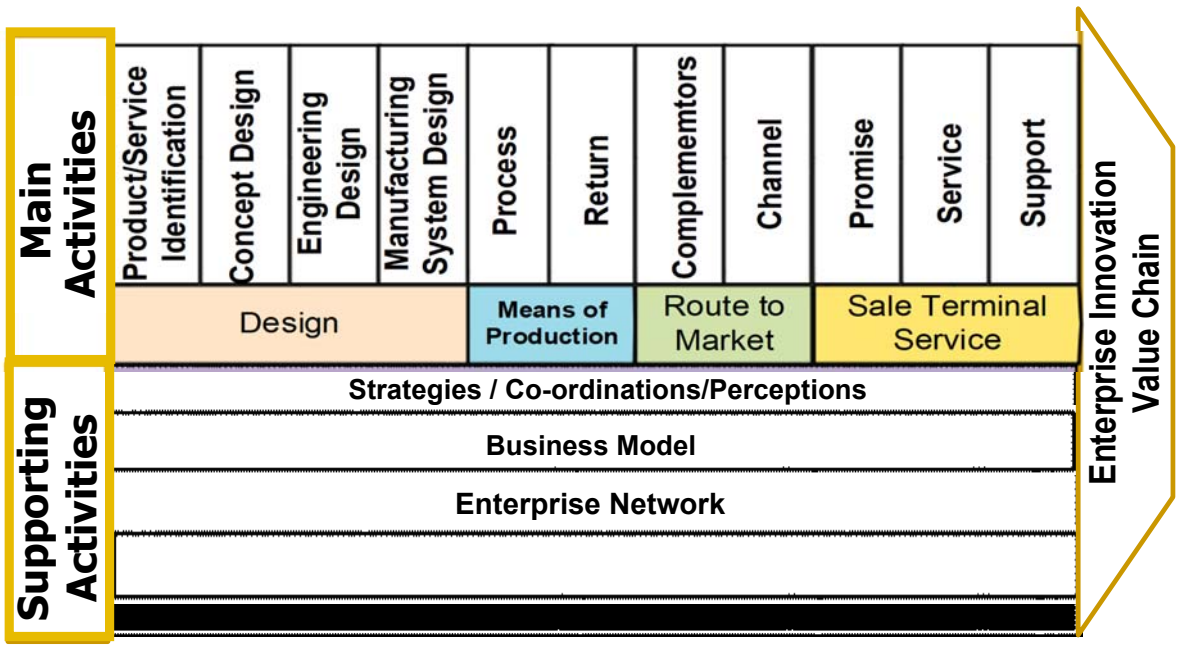
- Overview of Innovation Value Chain: Main flow & Supporting flow
- 7 pillars of TRIZ philosophy
- Research Oppr. in SI along the Innov. Value Chain: a landscaping of issues for R&A studies.

Systematic Process of Systematic Innovation (Main Activities)



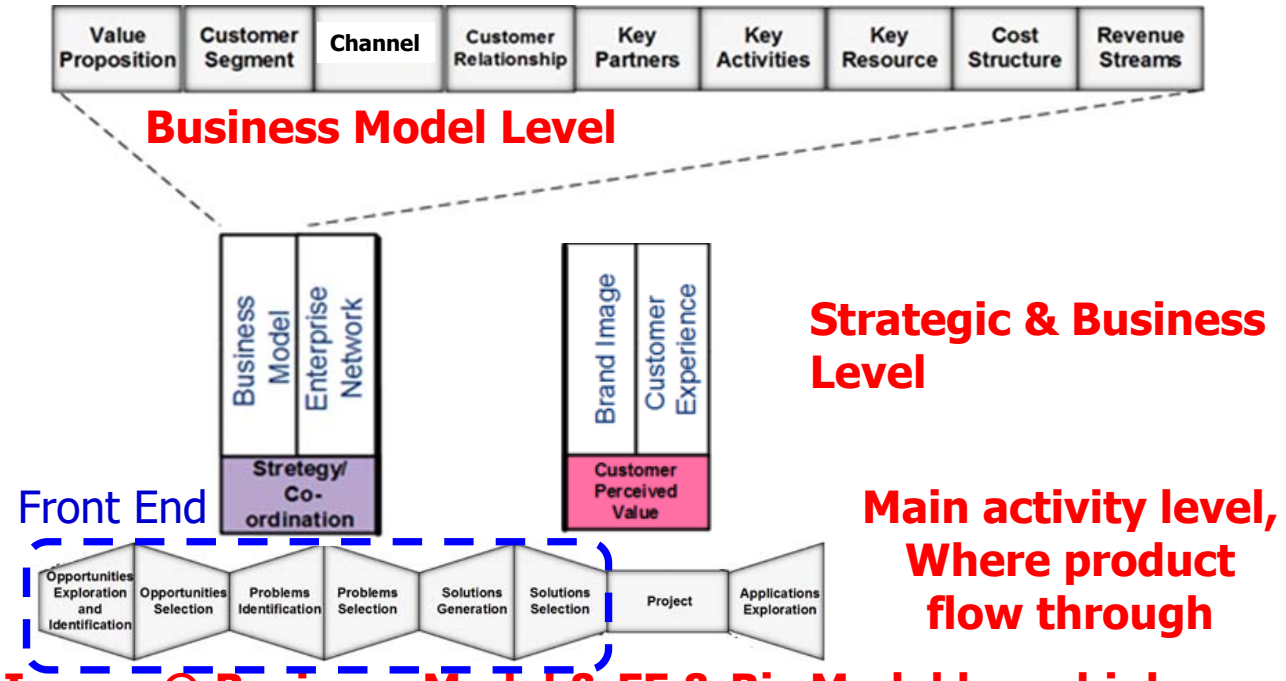
Oppr. in EVERY stage of process. The earlier the stage, the higher the impact.

Innovation Value Chain: Full picture & Overview



Every block in the chain has opportunities 4 Innovation

Construct of Innovation Value Chain



Innov. @ Business Model & FE & Biz Model have higher impacts. SI/TRIZ^{++} can contribute to all of them.

Consider Opportunities for Researches & Applications from 5 aspects

A) SI/TRIZ philosophy & overall Body of Knowledge
B) Business Management, Biz Model, Service areas
C) Technical Aspects of SI/TRIZ:
   - along innovation main value chain
   - Patent related
D) Emerging new methods/areas of researches
   - Using Mathematical/quantitative tools for TRIZ problem solving:
     - AI / Big data tools
   - TRIZ for Industry 4.0
   - IT/Automatic invention
E) Integration with other tools
   - 6 Sigma/Lean/TOC/VE /Kepner-Tregoe/Axiamatic Design/… (skim)

SI Working Philosophy: 7 Pillars of TRIZ

** Fundamental pillars for SI/TRIZ^{++} being powerful.

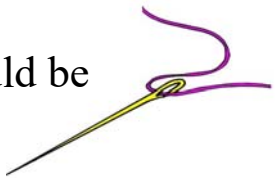
- Ideality: goodness index for all products/services
- Resources:
  - Achieving func./value with min. resource usage
    - Non-use to Useful (W2W)
    - Harm to Help (H2H)
- Functionality
- Contradiction
- Space-Time-Domain-Interface (STDI)
  - Seeing things from diff. perspectives.
  - Something may be difficult from one viewpoint, but can become easy to understand seeing from a different viewpoints.
- System Transfer (Sheu 2016)
- System Transition (Sheu 2016)

System Transfer

- **System Transfer**: When a problem occurs within a system, one can:
  - transfer the issue of solving the problem from within the system to a seemingly **unrelated** system and handle the problem in that unrelated system to solve the current problem.
- The novelty of the System Transfer:
  - Transferring the issue of the current system to a seemingly unrelated system to solve the problem often more elegantly and innovatively.

Example of system transfer: needle

- Needle:
  - For [O1]easy to thread, [P]size of needle eye should be [+P]big.
  - But
  - For [O2]not to damage cloth, [P] size of needle eye should be [-P]small.
- Parameter transfer:
  - In order not to damage cloth, let the needle eye small. transfer "easy to thread" to external threading device to achieve the goal.) → **threading device**



System Transition

- System Transition (Ts): Drastically change the subject system to solve problem.
  - Technical:
    - Paradigm shift: CRT -> LCD，Jump to next S-curve
    - Phase transition(Solid-liquid-gas-field)
    - Butterfly Metamorphosis;
  - Management:
    - Merging, Organizational structural Change, change biz model drastically, …

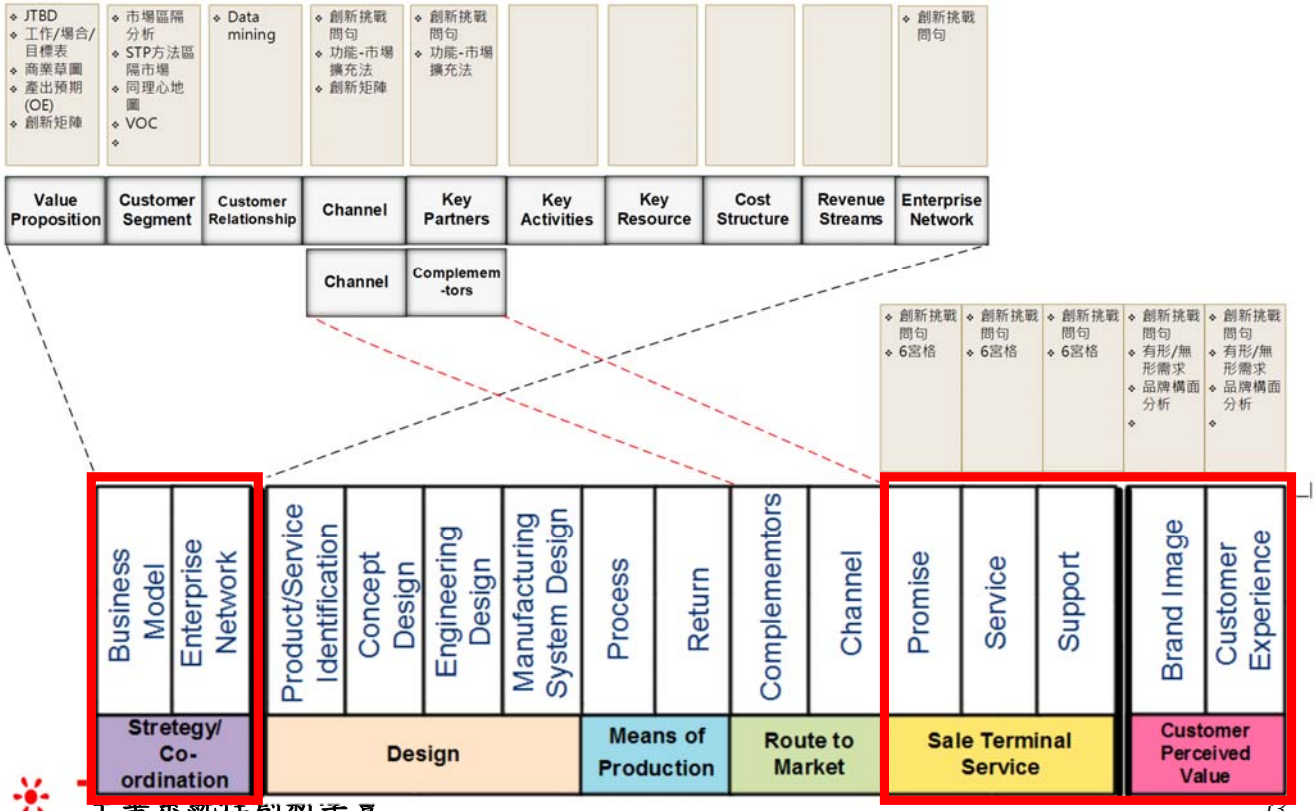
A1. Issues to study in SI philosophies

- Resources:
  - How to ID and use unused/unaware/non-intended resources?
  - How to ID OPR to convert harmful resources to useful?
  - How to ID business resources?
- STDI:
  - How to ID various/comprehensive viewpoints to see a problem? (deBono 6 Think Hats primarily on daily life issues not technical issues) Integration of TRIZ & deBono methods.
- Sys Transfer/Transition (Tf & Ts)
  - How to ID seemingly un-related system for problem transfer/solving?
  - How to ID system transition to solve problem and/or take advantage of new opportunities?

A2. BOK/tools along innovation value chain

- Positioning of existing and new tools in the stages of innovation value chain.
  - Where & how they can be used
  - How can they be integrated.
  - => create BOK of innovation value chain, Id problem solving tools for each stage.

Partial List of supporting Activities

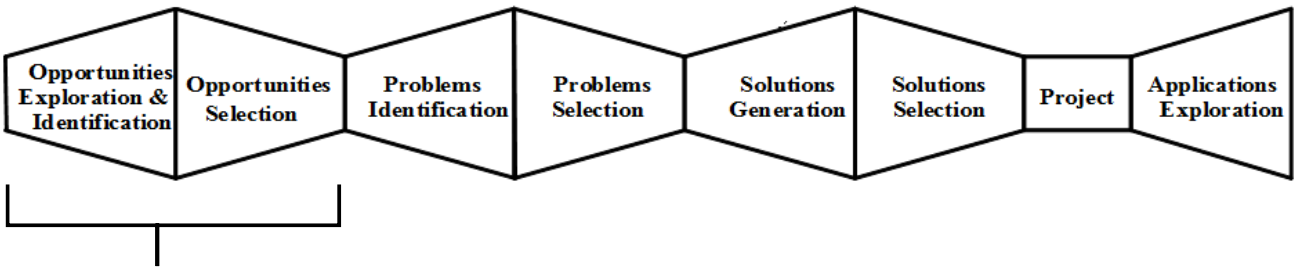


Opportunities Exploration and Identification (1)	Opportunities/ Problems Selection (2)	Problems Identification (3)	Problems Selection (4)	Solutions Generation (5)	Solutions Selection (6)	Project Execution (7)	Applications Exploration (8)
TRIZ tools: 9/12 Windows; Ideal Final Results (IFR); Evolution Potential Anal; Feature Transfer	(S-curve Analysis)	F(A)A; CE(C)CA; Root Contra. Anal. (RCoA); Func. Rel Anal; Size-Time-Interface-Cost (STIC); 9/12 Windows; Flow Analysis		Inv. PrinCiples; Sep. Prin/Sys Transition; Inventive STD; Solution Directives; Trends; Resources; Patent DB; FOS; (F/A) K/E DB; AFD; Trimming; SLP; Feature Trans.; Super Eff Ana.	{Topic for research : BOK of Innov. Value chain}		R-FOS
Non-TRIZ tools: Problem Hierarchy Ana; Ideal Final Attributes; Omega Life Views (OLV); VOC/QFD; Perception Mapping; 6 Think Hats; Hoshin Plan; Dominant Des.	Benefit Analysis; Constraint Analysis; Resource Analysis; Pugh Matrix; Feasibility Study	Red Team Analysis; Kepner Tregoe Method; 6 Thinking Hats; Lean (VSM)	Root Cause Anal. (RCaA); Red Team Analysis; Pugh Matrix; Kepner Tregoe method	Patent Circum.; Lateral Thinking; SCAMPER; Oblique Strategy; 6 SG	Multi-Criteria Decision Analysis; Axiomatic Design; Pugh Matrix	Proj. mgmt tools; Six Sigma; Lean Prod-uction; ...	VOC; Product Platform Analysis (PPA); Product/ Technology Roadmap

B) Business Mgmt, Biz Model, Service areas

- ID Biz contradictions & solve them with TRIZ/SI tools.
- ID Biz Opportunities and implement it
- Determine R&D strategy (trends)
- Biz model ID & develop in 12 elements:
  - Vision/Mission/Core capabilities/Value proposition/Customer Segment/Customer Relationship/Channel/Key Partner/Key Resources/Key Activity/Cost structure/Revenue Structure.
- SI tools for Service improvements.
- Management mechanism for SI/TRIZ introduction to industries.

C1) Research opport. along main chain



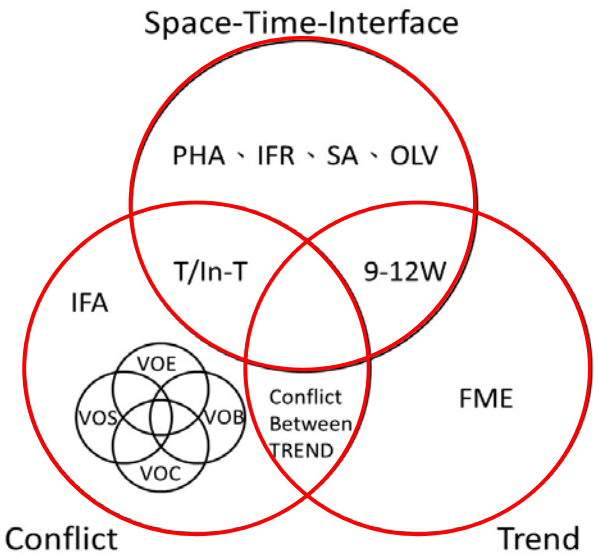
1. ID Innov. Product/Service Oppr.

Almost all existing methods are based on Customer Survey / Observations:

VOC/QFD
Design Thinking
Focus group …
Mostly still Random Innovation
(Process may be systematic, working tools are mostly Random)

TRIZ++ has 3 diff modes to ID opportunities.

TRIZ based modes



Mode 1：

Space-Time-Domain-Interface

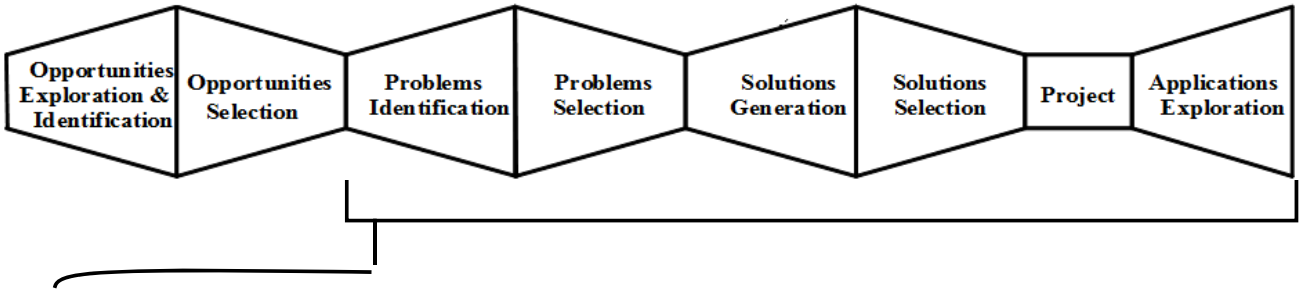
Mode 2：

ID non-obvious contradictions and solve them.

Mode 3：**Use Trends**：

- ID next trends stage earlier than competitors
- ID contradictions between trends and solve them

C2) Opportunities along IVC



- Integrated application of SI tools w/ non-TRIZ tools to solve problems
  - Islands of applications => Integrated/synergic appl. in Processes
  - Integrate w/ other tools to compliment one another:
    - 6σ/Lean/VE/KT/ FMEA/TOC/Axiomatic Design/ Optimization methods
- Adapt SI tools for specialty areas appl. Eg: Green Design/Recycling,…
- Dev. New tools (methods & S/W**)** w/i SI/TRIZ & next page

Develop New SI Tools

1. **More traditional scope of SI tools development and usage to solve Product/Process/Equipment problems**
   - Harmful/insufficient/excessive/ineffective problem solving
   - For Process Trimming, cost cutting, quality improvements, etc
   - Tech. forecasting, New trend & special S-curve ID.
   - Much more complete effect DB, …
2. **Dev. SI tools in new scope, eg:**
   - Modes of Innovations: (focus on "**How**")
     - Breakthrough Innovation: ((Step Jump) -> next S curve)
     - Disruptive Innovation: I= B/C: Benefits ↓; **Costs ↓↓ => I↑**
   - Failure ID for never-happened failures (Failure pre-emption)
   - Patent technology development:
     - Circumvention/Enhancement/Re-generation; Deployment, Mining
   - Patent text mining/analysis

Failure **Pre-emption** (失效先除)

- **Generations of equipment failure treatment** :
  1) Replace after failure (After the fact)
  2) Preventive Maintenance
     - Maybe over or under maintenance
  3) Prognostic maintenance (continue monitoring and calculation, stop Eqm before failure attack)
     - State of the art technology, still need to take down equipment.测
  4) Pre-emptive redesign (ID potential failure & redesign system): Design-in to Design-Out
- New tools may be developed to ID unknown failure and **design in mechanism to design out potential failu**re.

Considering Opportunities for Researches & Applications from 5 aspects

A) SI/TRIZ philosophy & overall Body of Knowledge
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C) Technical Aspects of SI/TRIZ:
   - along innovation main value chain
   - **Patent related: Textual vs Technical analysis**
D) Emerging new methods/areas of researches
   - Using Mathematical/quantitative tools for TRIZ problem solving:
     - AI / Big data tools
   - TRIZ for Industry 4.0
   - IT/Automatic invention
E) Integration with other tools
   - Lean / 6 Sigma / TOC/ VE /…

Background and Motivation

- **Logical reasoning vs mathematical calculations**
  - Using TRIZ to solve problem mostly relied on qualitative, logical identification and instead of quantitative/mathematical calculations. Especially, the process from model of problem to model of solution relied heavily on problem solvers' judgments and experiences.
- **The deficiencies are:**
  - When many models of solutions to look at. If experts identify possible solutions one by one. It will take a lot of time.
  - Different experts or different conditions often identify different solutions. Solutions are often subjectively selected and often non-repeatable across different problem solvers.
  - Some possible solutions are more relevant than others. Most possible solutions are not relevant to the current problem. Need to prioritize the solution based on their potential of problem solving for the subject problem.
- **Some times, TRIZ papers have not been well accepted by scientific Journals. => IJoSI**
  - Solution **repeatability** by different people. Some authors may **retrofit** TRIZ.
  - Use of quantitative/mathematical methods can be helpful.

OXFORD CREATIVITY

The Effects Database has 222 suggestions for Move Solid

Advection	Electrolysis	Lewis	Shaking
Aeolipile	Electromagnet	Light	Shape Memory Alloy
Aeroelastic Flutter	Electromagnetic Induction	Linear Motor	Shape Memory Polymer
Aerofoil	Electromechanical Film	Liquid-Liquid Extraction	Shock Wave
Angle of Repose	Electron Impact Desorption	Lorentz Force	Smoke
Angular Momentum	Electropermanent Magnet	Lotus Leaf Effect	Sol
Angular Momentum Conservation	Electrophoresis	Maglev	Solenoid
Archimedes Screw	Electrophoretic Deposition	Magnetic Field	Solvation
Archimedes' Principle (Buoyancy)	Electroplating	Magnetic Pulse Welding	Sound
Auxetic Materials	Electrostatic Deposition	Magnetic River	Spanish Windlass
Auxetic Structures	Electrostatic Fluid Accelerator	Magnetic Shape Memory	Sphericon
Ball	Electrostatic Induction	Magnetism	Spheroid
Bernoulli Effect	Electrostatics	Magnetoelastic Effects	Spring
Bi-Metallic Strip	Electrostriction	Magnetohydrodynamic Effect	Stewart Platform
Block and Tackle	Entropic Explosion	Magnetovolume Effect	Stick-slip Phenomenon
Boundary Layer	Erosion	Magnus Effect	Stirling Cycle
Bourdon Spring	Escapement	Mechanical Force	Stokes Drift
Brazil Nut Effect	Explosion	Meissner Body	Sublimation
Brownian Motion	Fan	Misznay-Schardin Effect	Suction
Brownian Motor	Ferromagnetism	Mixed Convection	Sun and Planet Gear
Brush	Fin	Möbius Strip	Superconductivity
Cam	Flocculation	Moment of Inertia	Surface Acoustic Wave
Catapult Effect	Fluid Spray	Nap	Surface of Constant Width
Centrifugal Force	Fluidisation	Negative Thermal Expansion	Swashplate
Cheerio Effect	Flywheel	Nuclear Fission	Tea Leaf Paradox
Chemical Transport Reactions	Foil (fluid mechanics)	Oloid	Tension

Examining 222 possible solutions one by one will be very time consuming – especially many of them are not familiar to most people. It may need a lot of time for background studies.

From Oxford Creativity: Accessed on 2014/7/20

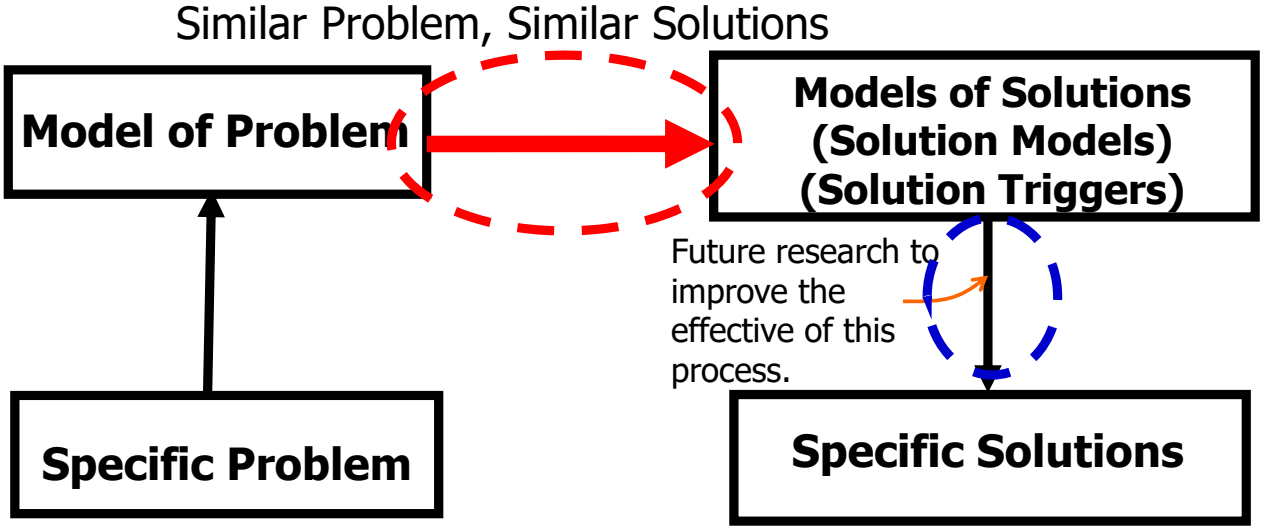
Rationale of the research

- It will be nice if there is a way to ID only small number of most likely solution models with priority to save problem solver's time.
  - 222 Effect suggestions => 5~10 most likely suggestions. (Save 95% of time during this stage. 10/222 ~= 5%)
  - 51 trends => 5~8 most likely trends. (save 83% of time during this stage)
  - 76 standards => 5 most likely ones. (save 93% of time during this stage)
  - … (for any DB that has large options to choose from.)

New Dir.: Quantitative/math. Tools

TRIZ Model of Problem Solving

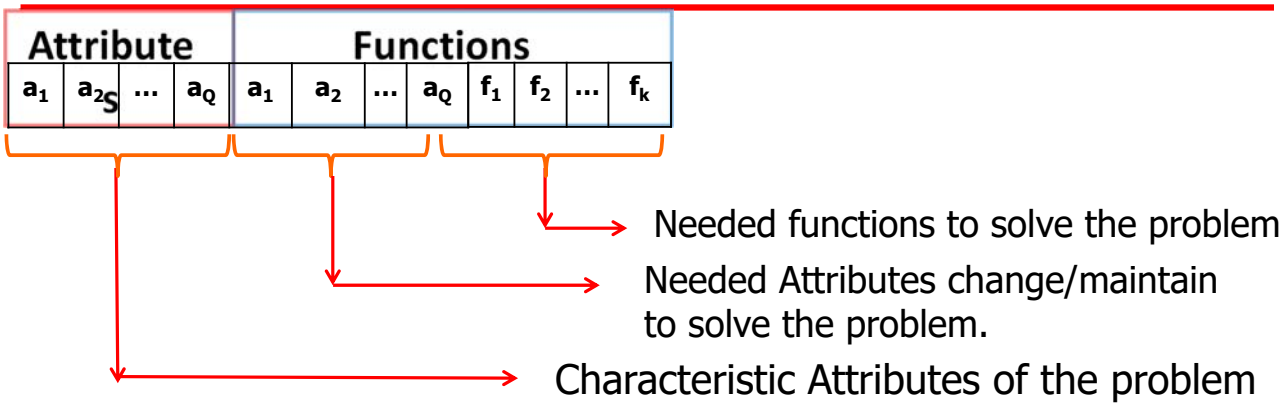
222 Effects, 52 trends,
76 standards, etc.



Key concepts

- Adv. of using Mathematical/quantitative Methods to ID Model of solutions:
  - Prioritized, Repeatable, Objective, Faster by computer, easier to accumulate expert knowledge/experiences.
- Concept 1: Computable Problem & Solution models
  - Problem models into Problem Characteristic Array (PCA),
  - Solution models into Solution Array (SA), and
  - Use attribute / function arrays to fully characterize problem / solution
- Concept 2: convert the problem of ID relevant solution models to Binary Classification problems
- Concept 3: Use Similarity measures to determine priorities of various potential solutions. Like problem like solution.

Problem Characteristic Array (PCA)



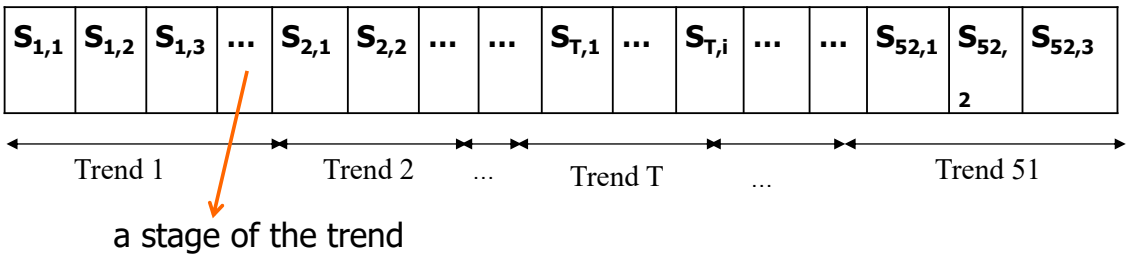
In each field: 1: indicate that this attribute/function is relevant to this problem.
0: indicate that this attribute/function is irrelevant to this problem.

PCA:

- Facilitates similarity comparison between problems. (Binary bit array)
- Fully defines a problem for solution screening & prioritization.
- Possible future extension to include Solution constraints/ Resources availability, etc. to characterize the problem in more granularity.

Solution Array: Trend ID as **example**

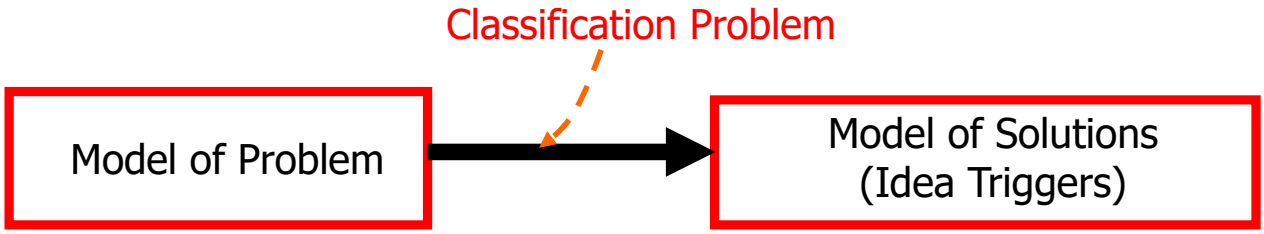
Solution Array with Trends and stages indicated.



$S_{i,j}$: stands for the *j-th* stage of the *i-th* trend.
A "1" at $S_{i,j}$ indicates that the *j-th* stage of the *i-th* trend is a solution of the problem. Otherwise, it is marked as "0".

- A solution array standardizes and fully represents a solution model for solving the problem.
- Fuzziness can be introduced for PCA / SA

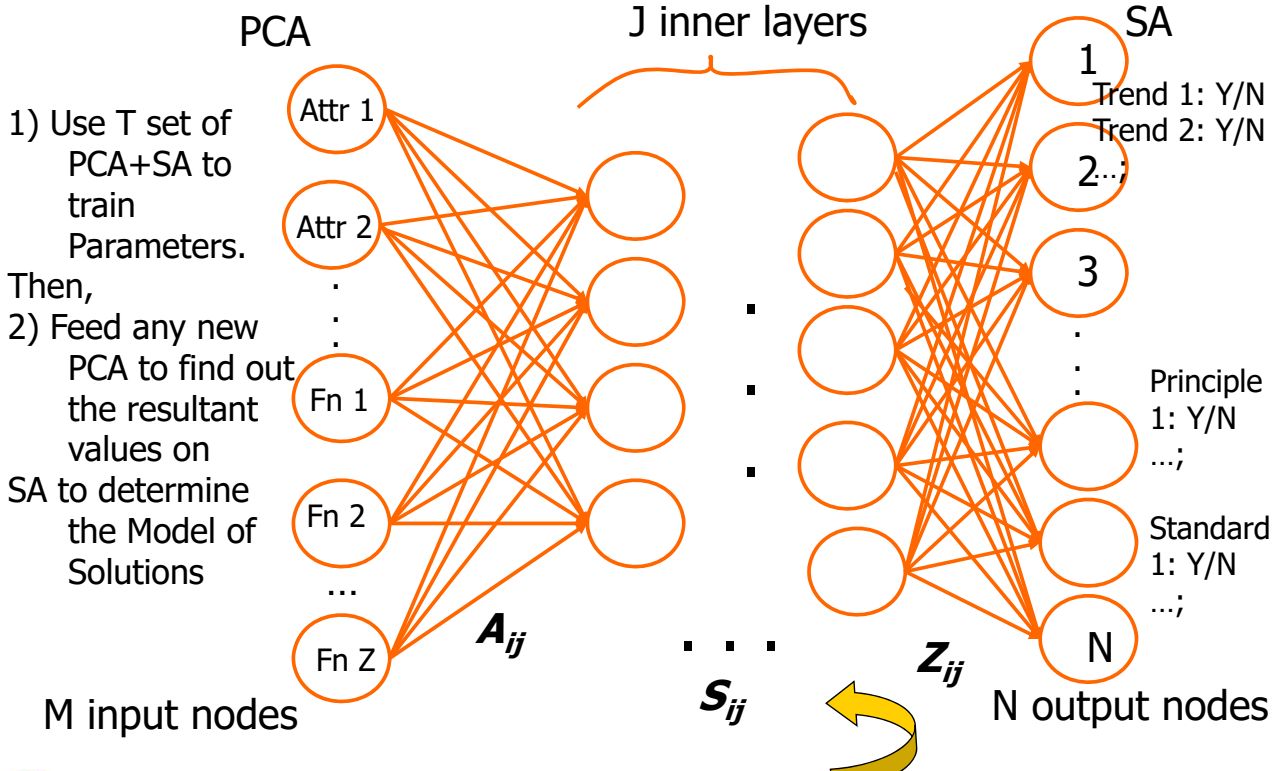
Key Concept 2



Like Problem, Like Solutions

- ID model of solutions (Model of Problem -> Model of Solution) is equivalent to a classification problem.
  - **For each problem (PCA), we simply classify each possible solution as either a relevant solution or NOT a relevant solution.**
  - A training set of solved problems can be used to build the **Classification Engine**/CE (determining parameter values of CE); Then, each new problem can be fed into the classification engine and resultant classes (Y/N my solution) can be determined for each solution model.

Example of using Neural Network (Trend)



Concept 3: Prioritization by Similarity

Numerous similarity measurement methods exist to indicate the similarity between *I* and *J*. (Choi et al., 2010; Donald et al., 1989; and Meyer et al., 2004). Ten mostly used measurements:

$$S_{JACCARD}=\frac{a}{a+b+c} \quad (1)$$

$$S_{Dice}=\frac{2a}{2a+b+c} \quad (2)$$

$$S_{Anderberg}=\frac{a}{a+2(b+c)} \quad (3)$$

$$S_{RUSSELL\&RAO}=\frac{a}{a+b+c+d} \quad (4)$$

$$S_{SOKAL\&MICHENER}=\frac{a+d}{a+b+c+d} \quad (5)$$

$$S_{PEARSON\&HERON-I}=\frac{ad-bc}{\sqrt{(a+b)(a+c)(d+b)(d+c)}} \quad (6)$$

$$S_{OCHIAI}=\frac{a}{\sqrt{(a+b)(a+c)}} \quad (7)$$

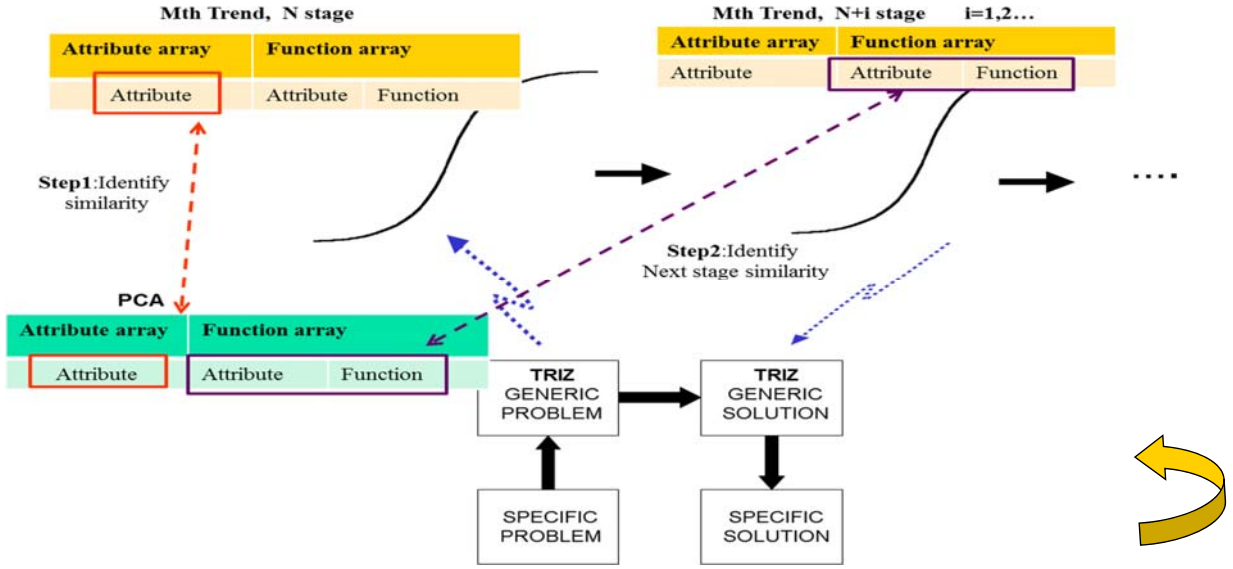
$$S_{OCHIAI-II}=\frac{ad}{\sqrt{(a+b)(a+c)(d+b)(d+c)}} \quad (8)$$

$$S_{YULEQ}=\frac{ad-bc}{ad+bc} \quad (9)$$

$$S_{ROGER\&TANIMOTO}=\frac{a+d}{a+2(b+c)+d} \quad (10)$$

Compare PCA of the problem w/ TCA

Obvious-sequence evolutionary stages:



- If the attributes array of the problem is similar to Mth trends Nth stage, we identify they are similar problems. Moreover, if some stage later of the trend provide desired functions of problem, the trend/stage may be as a problem solution.

Ample Mathematical tools available 4 **Classification & Decision making**

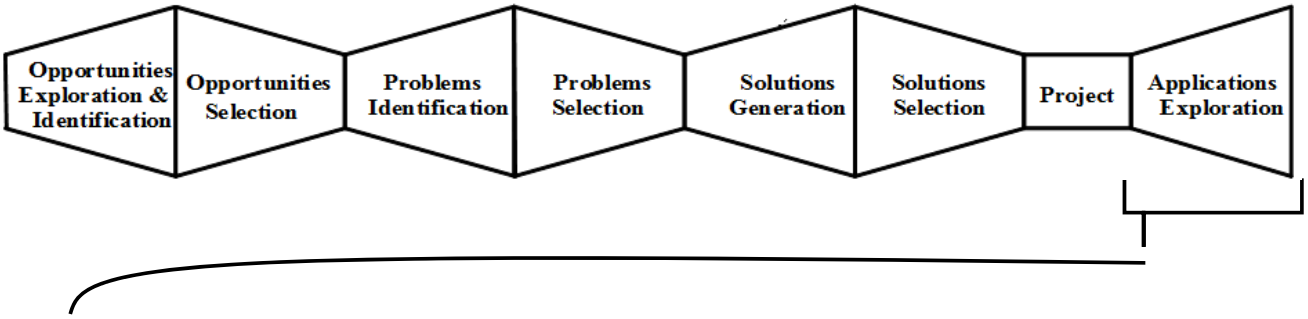
- Decision tree analysis (favored path vs unfavorable path)
- Similarity rating (> 30 ways of similarity measures published)
- Clustering techniques
- Neural network technique
- Support Vector Machine
- Mahalanobis-Taguchi System, MTS
- Case-based reasoning, … many more

(can use AI and Big Data technologies. AI/BD for SI/TRIZ++)

Ref:

- Sheu, D. Daniel and Jealousy Hong (2018), *Prioritized Relevant Effect Identification for Problem Solving Based on Similarity Measures*, Expert Systems With Applications 100 (2018) 211–223. https://doi.org/10.1016/j.eswa.2018.01.032 (SCI/3.928).
- Sheu, D. Daniel and Sheng Chia Chiu. (2017). *Prioritized Relevant Trend Identification for Problem Solving Based on Quantitative Measures*, Computers & Industrial Engineering, 107 (2017) 327–344 (DOI:10.1016/j.cie.2016.03.028.) (SCI/3.195)

Opportunities for Researches



8. Explore new appl. (Tech./product)
Develop tools to systematically ID new oppor. To expand the usage of the newly developed technology or product. Across different fields.

Call for papers/projects

10th International Conference and Global Competition on Systematic Innovation

2019.07.08-11, Univ. of Liverpool, UK

www.i-sim.org.tw/icsi2019

- 2019 ICSI/GCSI:
  - Global Competition on Systematic Innovation
  - Pre-conf. Scenic & Technical tours
    - Free pre-conference tour (7/8) for first 40 international participants.
- Related Journals: (Timely submission of FULL paper)
  - Special issue on IJoSI (International Journal of Systematic Innovation). (SCOPUS)
  - International Journal of Logistics: Research & Application (SSCI)
  - Engineering Design & Innovation Methods: Computers & Industrial Engineering (SCI)

The End.

Thanks for Listening!

Comments Welcome.

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