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BIG DATA, CYBER SECURITY AND PRIVACY ISSUES IN SMART GRID SYSTEMS

Prof. Dr. Şeref SAĞIROĞLU
Gazi University Computer Engineering Department, Ankara, Türkiye
ss@gazi.edu.tr

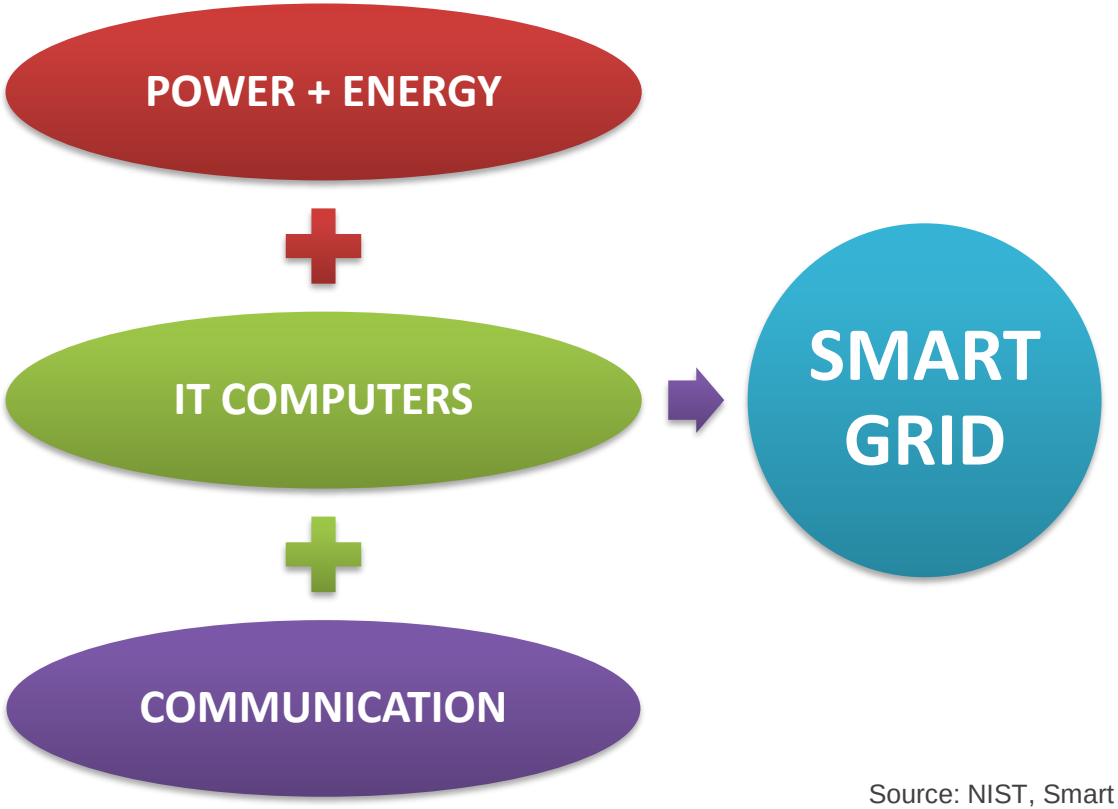
CONTENTS

- Smart grid world
- Perspectives
  - cyber security
  - big data and
  - privacy
- BD, CS, and Privacy Issues in SG
- Conclusion

SMART WORLD

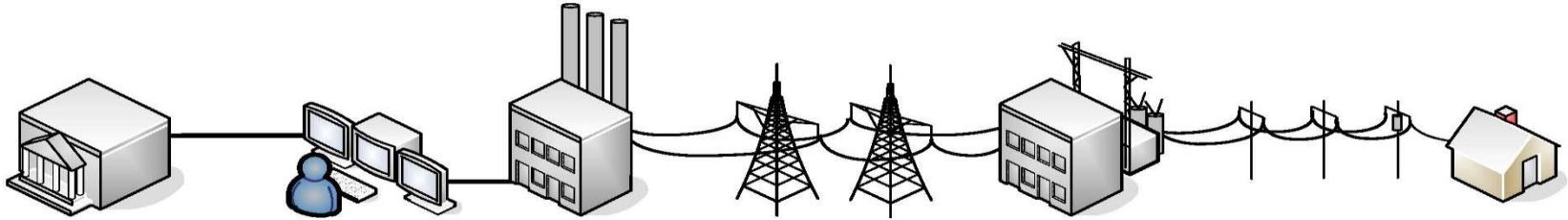
https://aliga.sk/en/what-the-heck-is-a-smart-city/

SMART GRID : DEFINITION (systems of systems)



Source: NIST, Smart Grid Conceptual Model

SMART GRID SYSTEMS

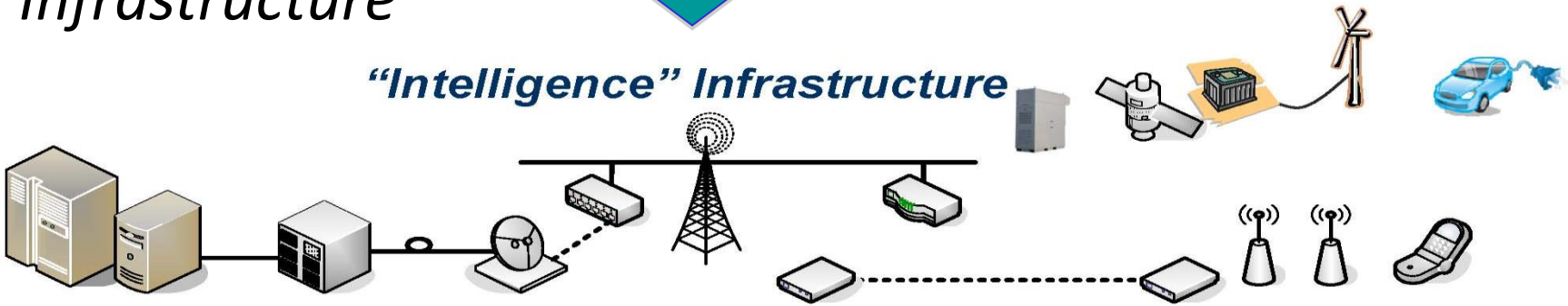


Electrical Infrastructure

Enabled by ICT Infrastructure

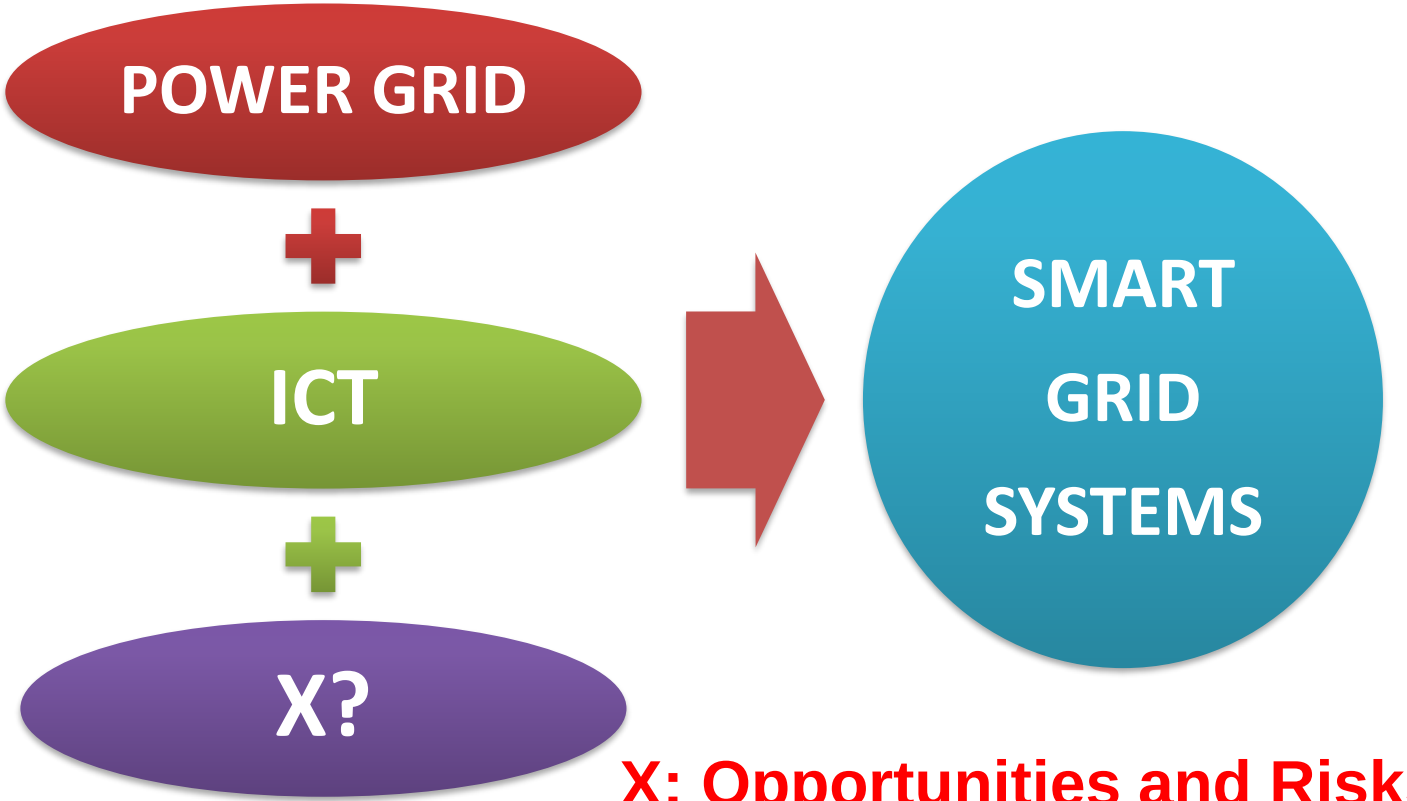
2-way flow of electricity and information

"Intelligence" Infrastructure



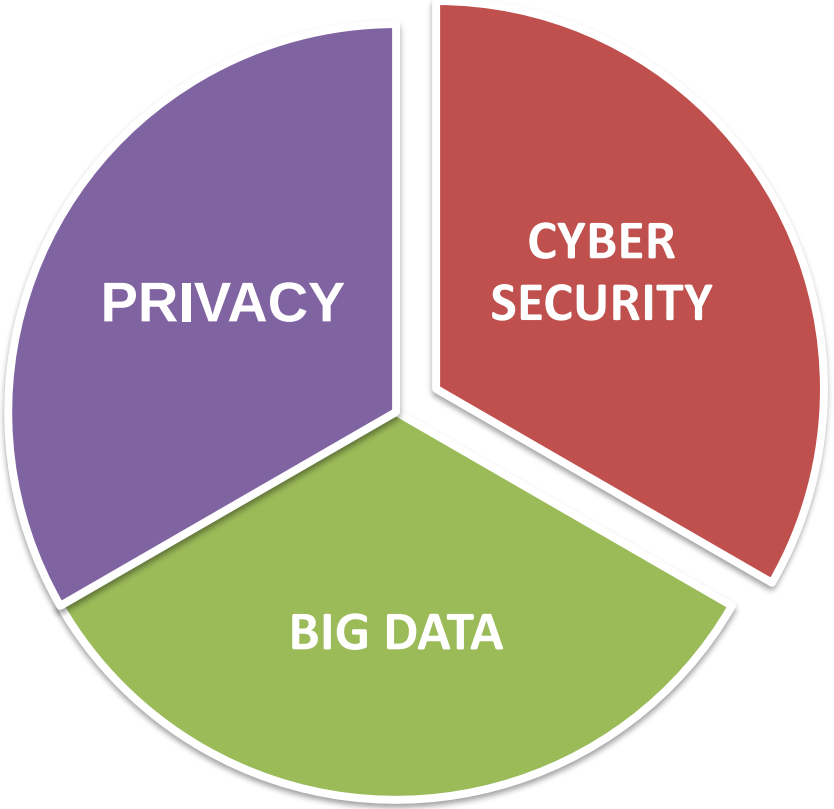
Source: ITU Symposium-ICT, May 30, 2012

SMART GRID SYSTEMS



X: Opportunities and Risks

SMART GRID WORLD



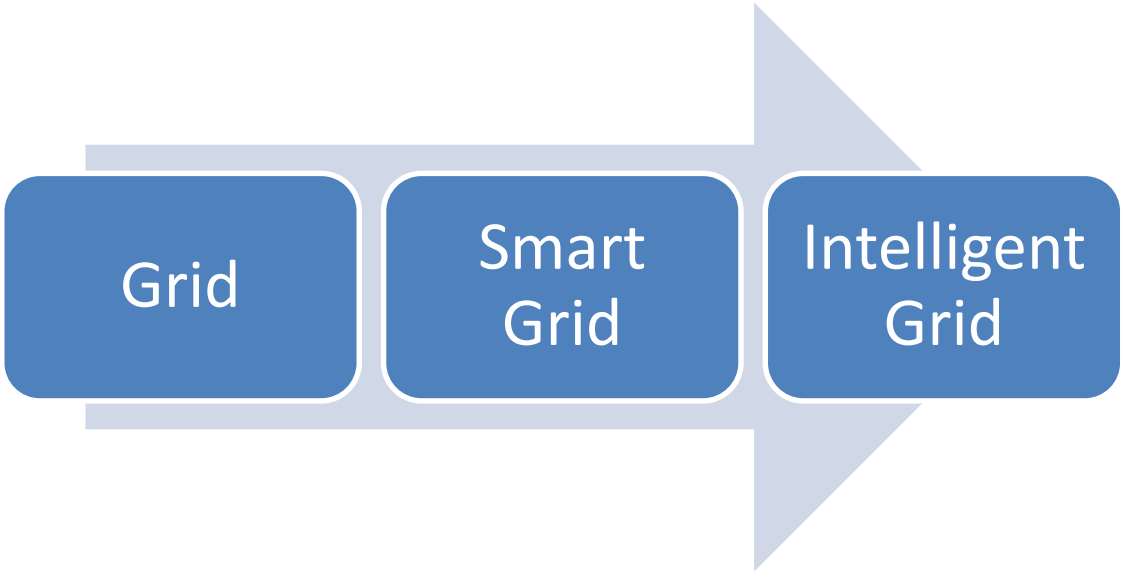
EXPECTATIONS FROM SMART GRID

- reducing cost in **production & distribution**
- data driven **pricing for consumption**
- better **monitoring and control**
- using more facilities of recent developments
- supporting high **quality services**
- **planning t**he changing demands of electricity consumption,
- **handling features** of reliable, efficient, clean and sustainable management

EXPECTATIONS FROM SMART GRID

- save more money over next decade
- provide secure communication
- more benefit and income
- reducing CO_2
- supporting EU Green Deal
- producing more renewable energy
- reducing energy consumption
- ...

EXPECTATIONS FROM SMART GRID

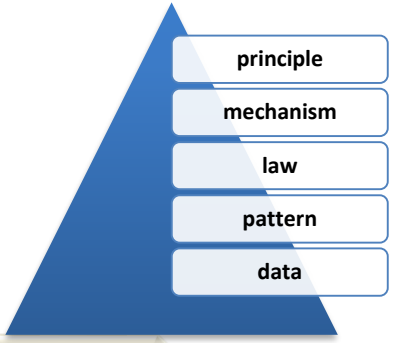


SMART GRID WORLD

- SMART GRIDS
- BIG DATA
- CYBER SECURITY
- PRIVACY

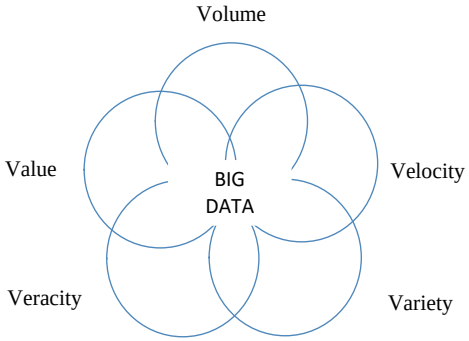
DATA AND BEYOND

- 1830 Statistics
- 1980 Data Mining
- 1989 Knowledge Discovery in Data
- 1997 Business Analytics
- 2002 Predictive Analytics
- 2011 Data Analytics
- 2011 Data Science
- 2012 Big Data
- 2016 Smart Big Data
- 2022 Generative Big Data



Kobielus defines as a superset of Big Data.
“ability to achieve big insights from trusted, contextualized, relevant, cognitive, predictive and consumable data at any scale, great or small.”
even **small data** can drive for **smart decisions** if it has these attributes.

BIG DATA 5 V'S



Volume : Number of records

Velocity : The frequency of data generation or transfer

Variety : Large diversity of data sources, formats and multidimensional fields

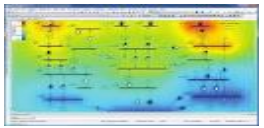
Veracity : The quality and reliability of data

Value : Insights and benefits from data

- **Viscosity**
- **Virality**
- **Visulisation**
- **Variability**
- **Validity**
- **Venue**
- **Vocabulary**
- **Vagueness**
- **Vulnerability**
- **…**

DATA SOURCES OF GRID

Weather



Simulation

Asset Inventory

Social Media

SCADA

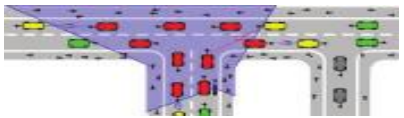
Smart Appliances/ sensors

BIG DATA

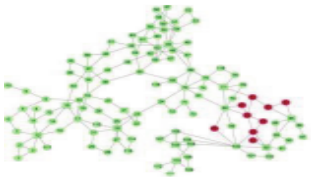
User/Operators Input

Smart Meters

PMUs/ μPMUs/ Sample Value



Traffic



Network (Power/Communication)

GIS

Field Measurement Units/RTUs

Source: BDAs in SGs: State-of-the-Art, Challenges, Opportunities, and Future Directions, IET Generation, Transmission and Distribution

BIG DATA PROCESS

COLLECT

PRE PROCESS

DATA CLEANING

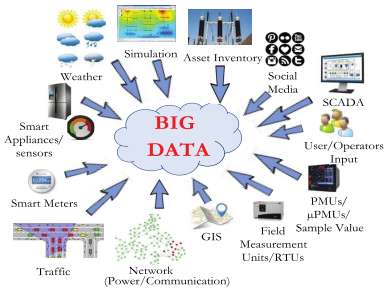
ANALYTIC

MODEL ALGORITHM

DATA VALUED

VISUALISATION

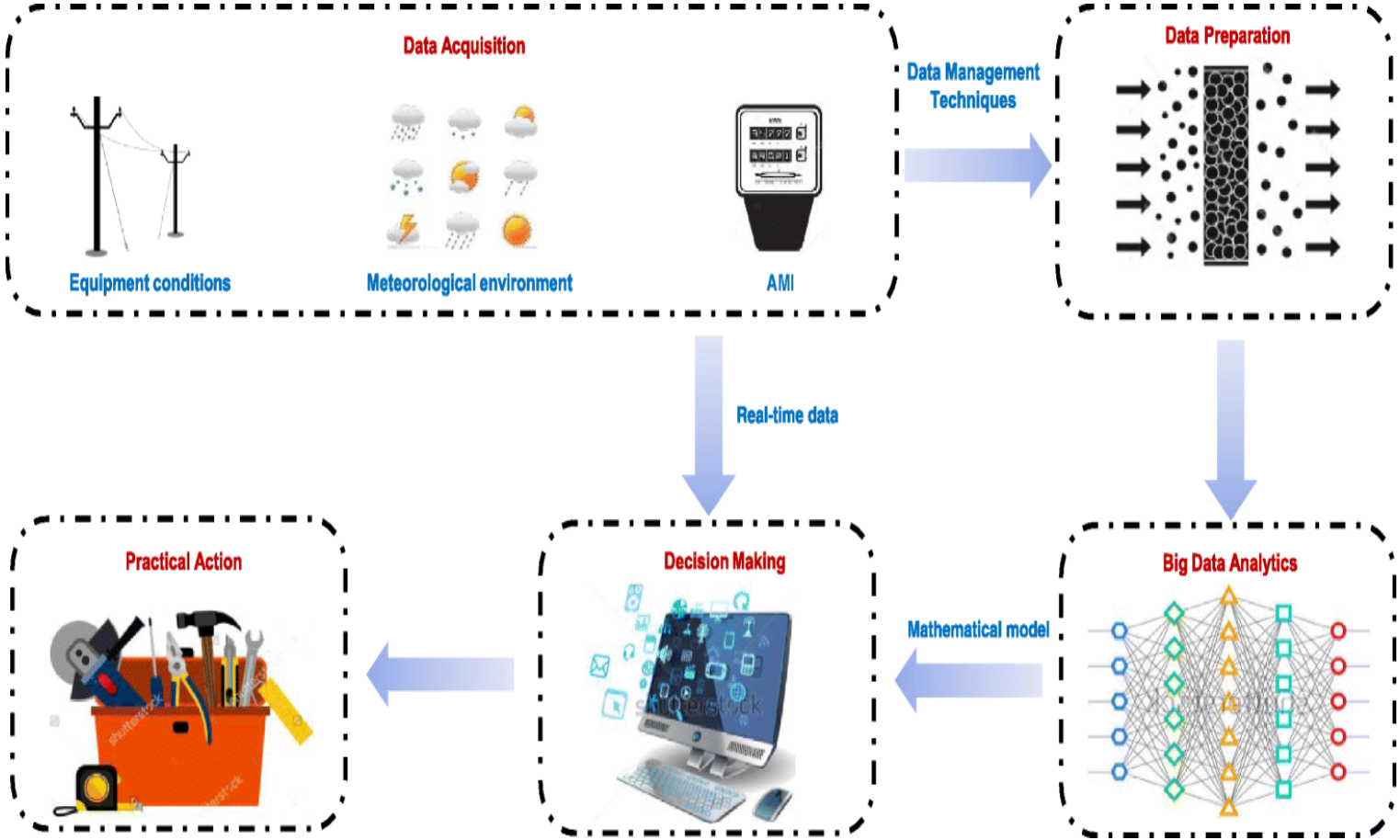
DECISION



- PRE-PROCESSING
  - INTEGRATING COMBINING
    - ENTITY IDENTIFICATION
    - REDUCTANCY IDENTIFICATION
  - CLEANING FILTERING
    - MISSING DATA
    - ABNORMAL DATA
  - TRANSFORMATION
    - STANDARDIZATION
    - DISCRETIZATION
    - ATTRIBUTE ABSTRACTION
  - ANONYMIZATION PRESERVING
    - DIFFERENCIAL PRIVACY
    - DATA ENCRYPTION
    - PRIVACY PRESERVING

- SUPERVISED TECHNIQUES
  - DECISION TREE
  - NAVIE BIAS
  - SVM
  - K-NN
  - RANDOM FOREST
- UNSUPERVISED TECHNIQUES
  - K-MEANS
  - K-MEDOIDS
  - HIERARCHICAL CLUSTERING
  - DBSCAN
  - EXPECTATION-MAXIMIZATION
- DIMENTIONALITY REDUCTION TECHNIQUES
  - PCA
  - SOM
  - RANDOM MATRIX

BIG DATA PROCESS IN SMART GRID



Zhang,Y.,Huang,T.&Bompard,E.F. Big data analytics in smart grids: a review. *Energy Inform*, 8. https://doi.org/10.1186/s42162-018-0007-5

BIG DATA ISSUES IN SMART GRID

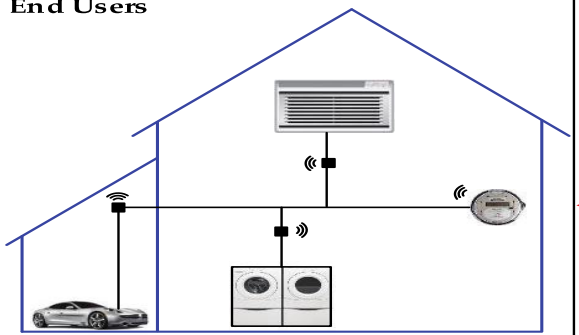
- Energy Forecasting
- Price Forecasting
- Risk Analysis
- Revenue Managment

Market Operators

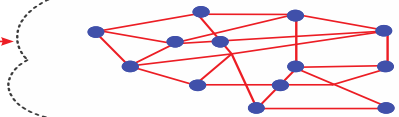
- Wide area control
- State Estimation
- Stability enhancements
- Real-time Monitoring
- Congestion Management
- Visualization

Transmission Operators

End Users



- Demand Response
- Load Forecasting
- Real-time Energy Management
- Customer Behaviors

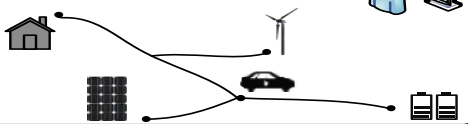


Data Hub

Generation Control Center

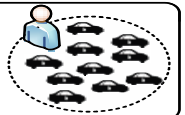
- Generation Planning
- Economic Load Dispatch

Distribution Operators



- Real-time operations
- Equipment health monitoring
- Asset management
- Planning
- Forecasting

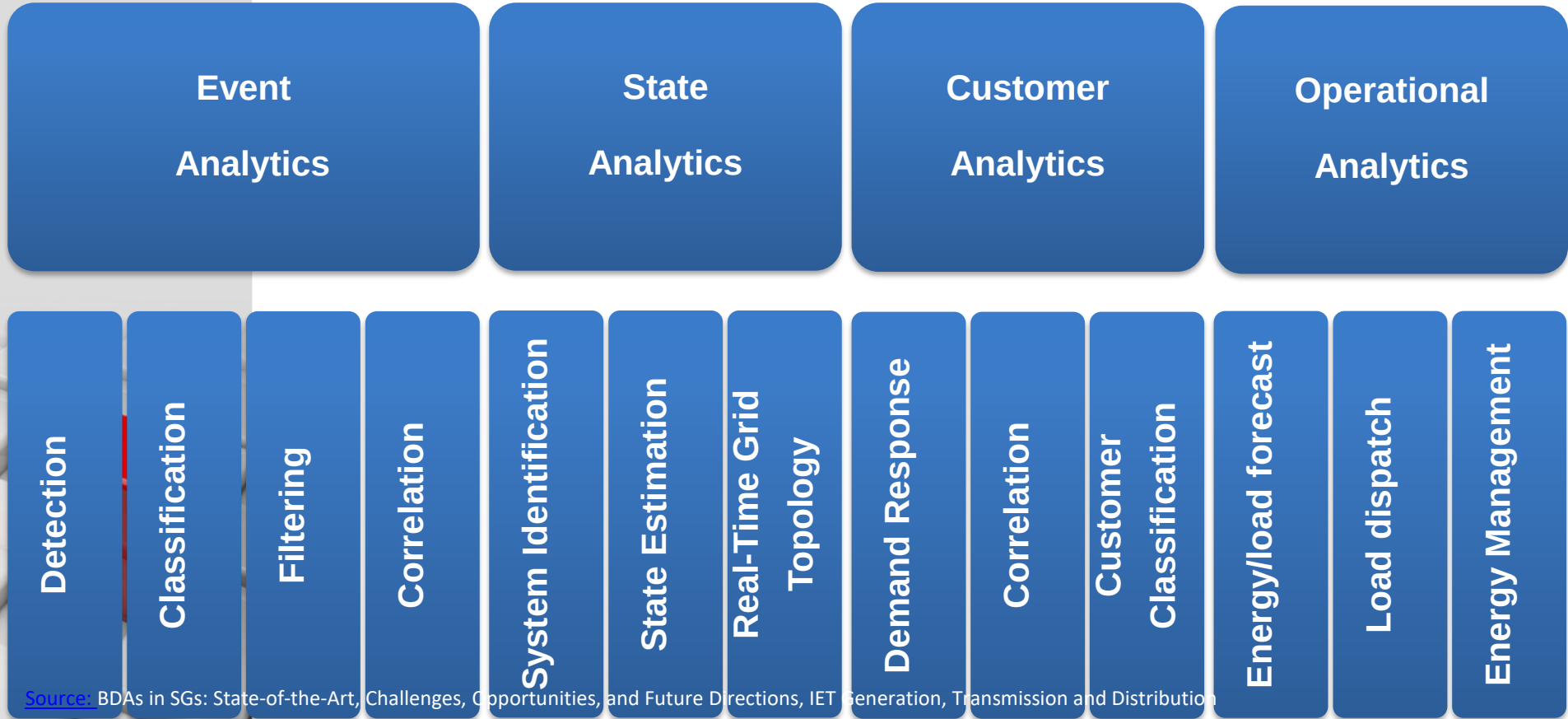
Aggregators/ other Businesses



- Flexibility Assessment
- Risk Analysis
- Forecasting

Source: BDAs in SGs: State-of-the-Art, Challenges, Opportunities, and Future Directions, IET Generation, Transmission and Distribution

Smart Grid Data Analytics



Source: BDAs in SGs: State-of-the-Art, Challenges, Opportunities, and Future Directions, IET Generation, Transmission and Distribution

SMART GRID WORLD

SMART GRID

BIG DATA

CYBER SECURITY

PRIVACY

PRIVACY CONCERN IN SMART GRID

Privacy means different things in different countries and regions; serious problem on internet;

- Bodily privacy
- Communication privacy
  - against eavesdropping
  - electronic communication privacy
- Identity privacy
  - anonymity
- **Data privacy**
  - rights to control collection, uses & dissemination of non-public personal info

Source: **Data Privacy, Michael I. Shamos,** Institute for Software Research School of Computer Science Carnegie Mellon University

PRIVACY CONCERN IN SMART GRID

Threats to privacy violation increase:

- Residential load profile
- Reveal our lifestyle from load signature (Refrigerator, Kettle, Washing machine, Toaster, Television, etc.)
  - Load profile
  - User profile
  - Health profile

PRIVACY CONCERN IN SMART GRID

- Attackers/criminals can use data to find out many weaknesses.
- Health companies can determine which medical device needed
- Insurance companies can provide different insurance rate
- House holders can predict how many people live in a house
- Privacy

  (shower, values, preferences, time out, etc.)

PRIVACY CONCERN IN SMART GRID

There are solutions:

- Data encryption
- Electronic signature
- Message authentication
- ICT solutions
- Anonymization

but

- Anonimized data
- Encrypted data

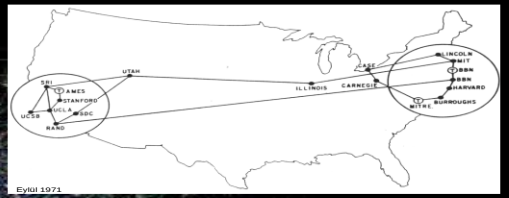
SMART GRID WORLD

SMART GRID

BIG DATA

CYBER SECURITY

PRIVACY



How do we understand cyber world?

Resource: http:// www. physorg.com/news151162452.html

THOUGHTS FROM FRONTIERS

- “Cyber crime is the most dangerous threat for companies”

  IBM President, CEO: Ginni Rometty

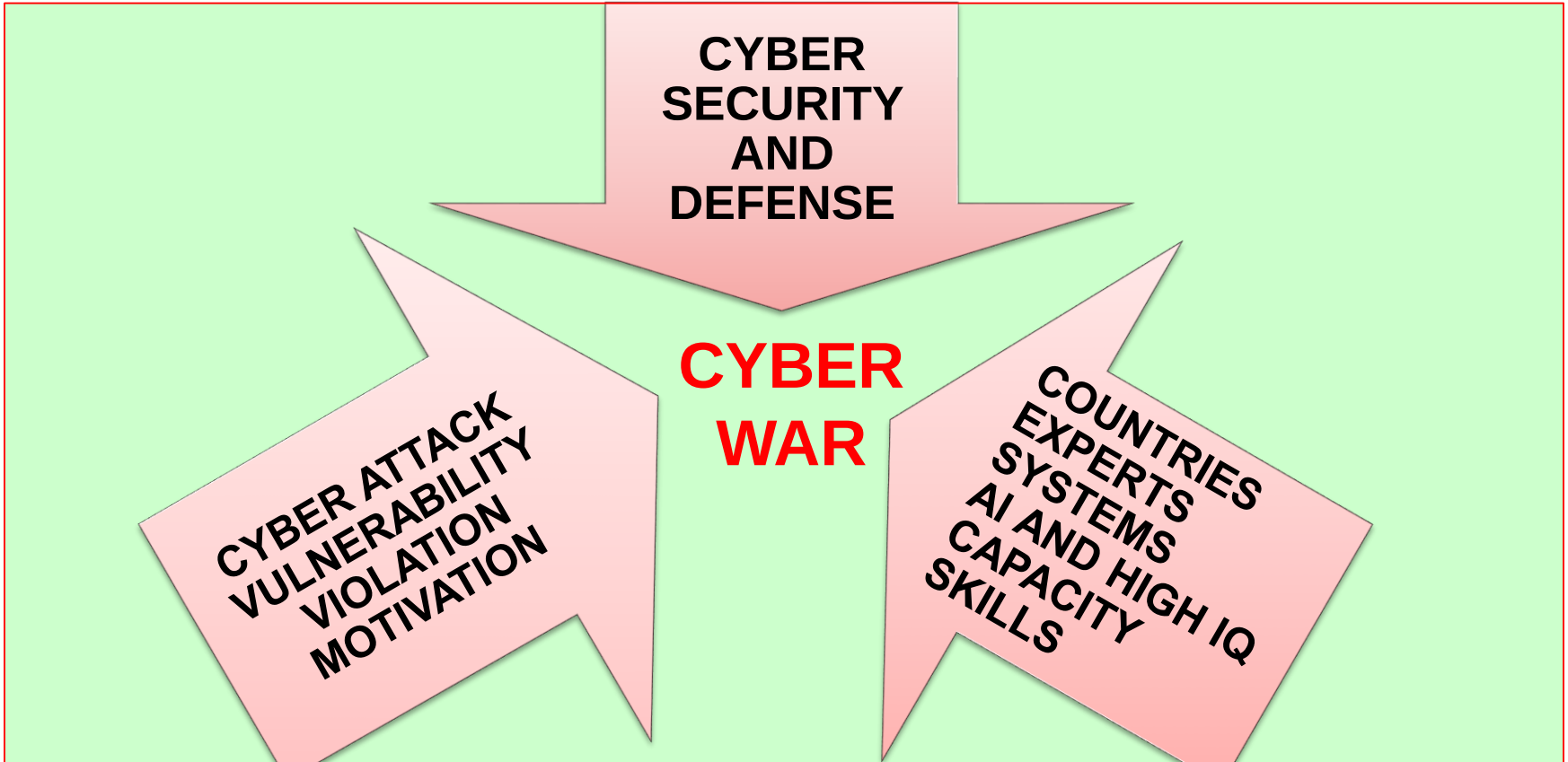
- “Cyber Security is Number One Problem”
- “Cyber attacks are more dangerous than nuclear weapons”

  Warren Buffett, Businessman

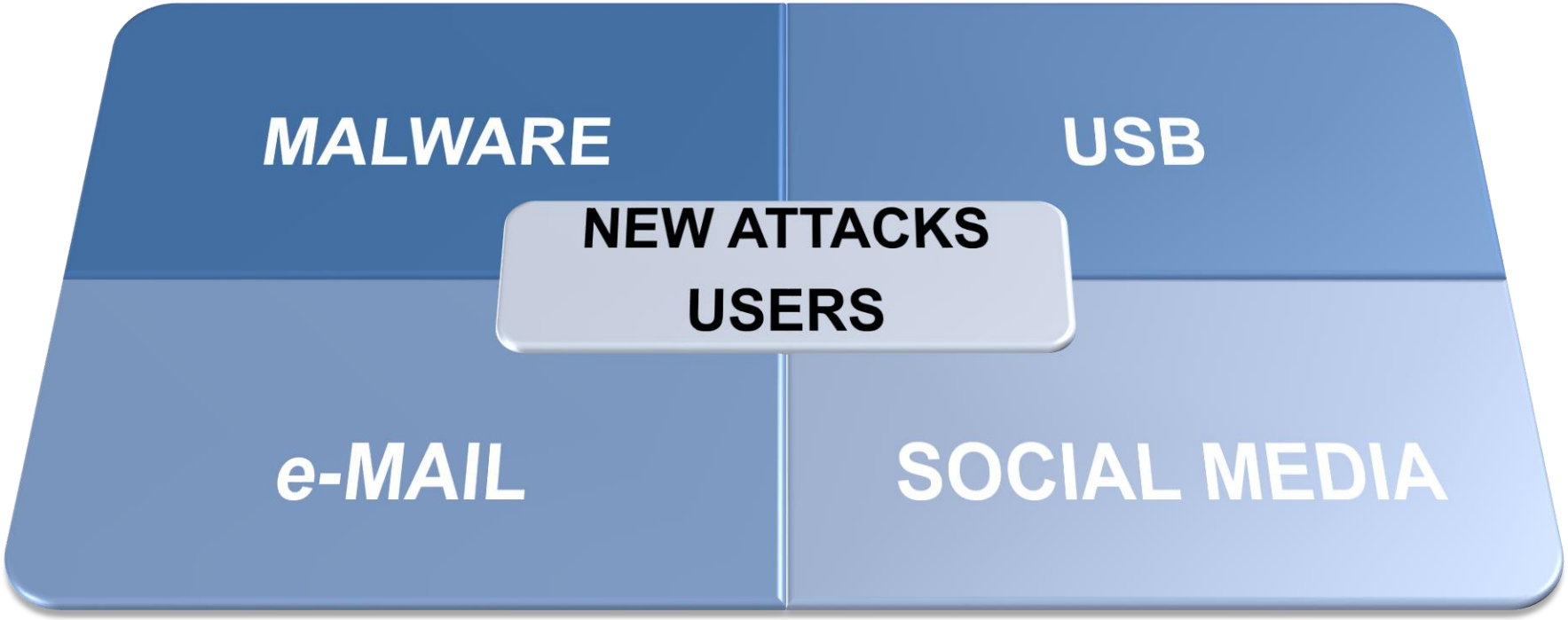
- “Cyber-Security is much more than a matter of IT, it takes 20 years to build a reputation and few minutes of cyber incident to ruin it.”

  Stephane Nappo. Global Cyber Security Officer

LIVING IN A WAR

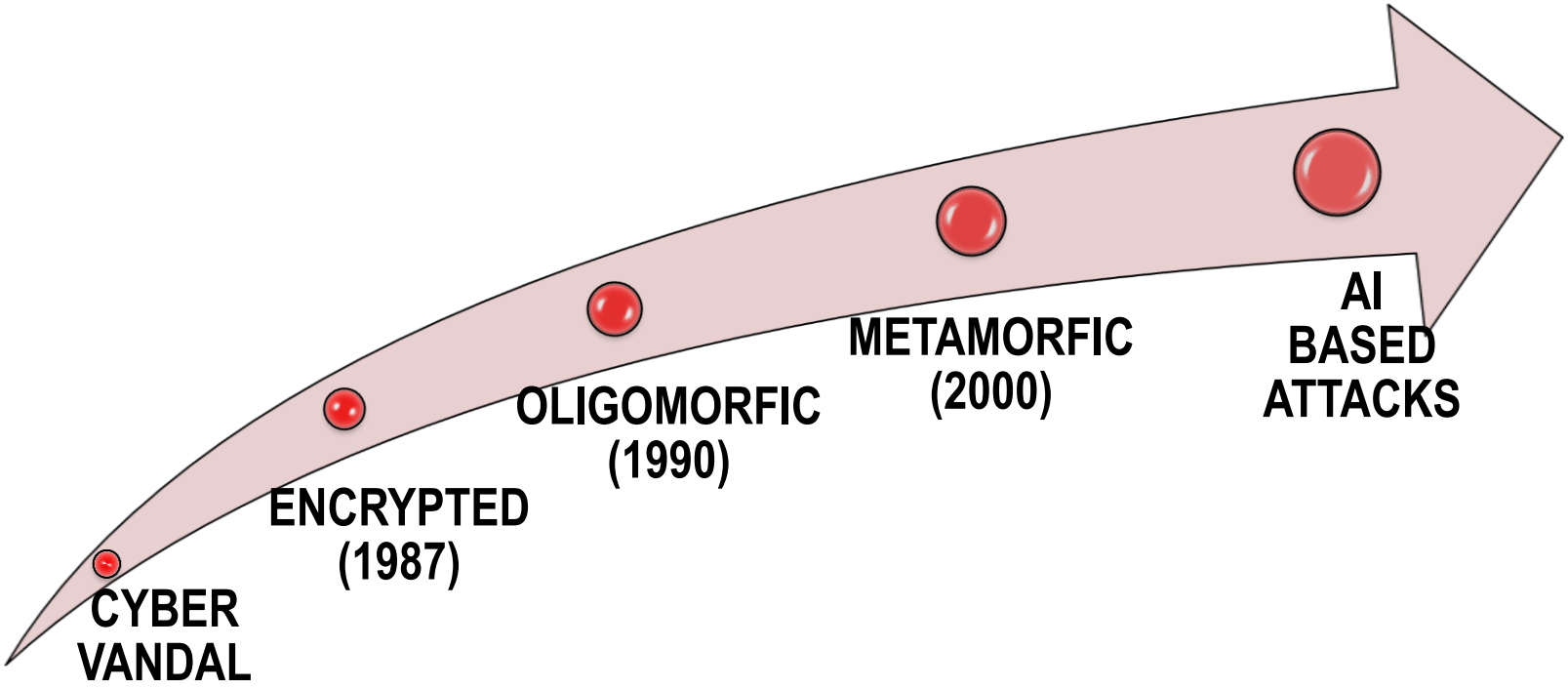


VULNERABILITIES USED

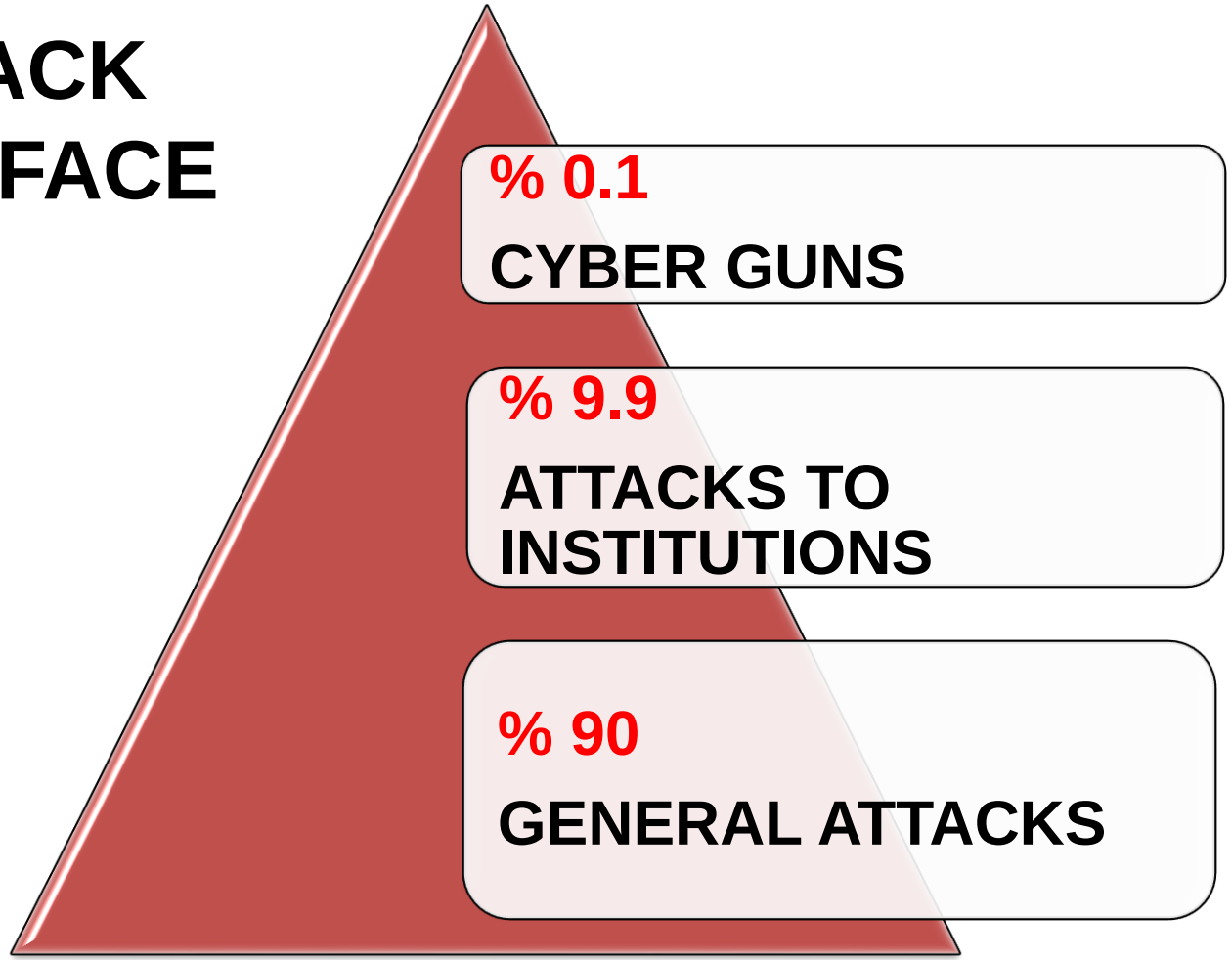


Source: KARSPERSKY

CYBER ATTACKS DEVELOPMENT



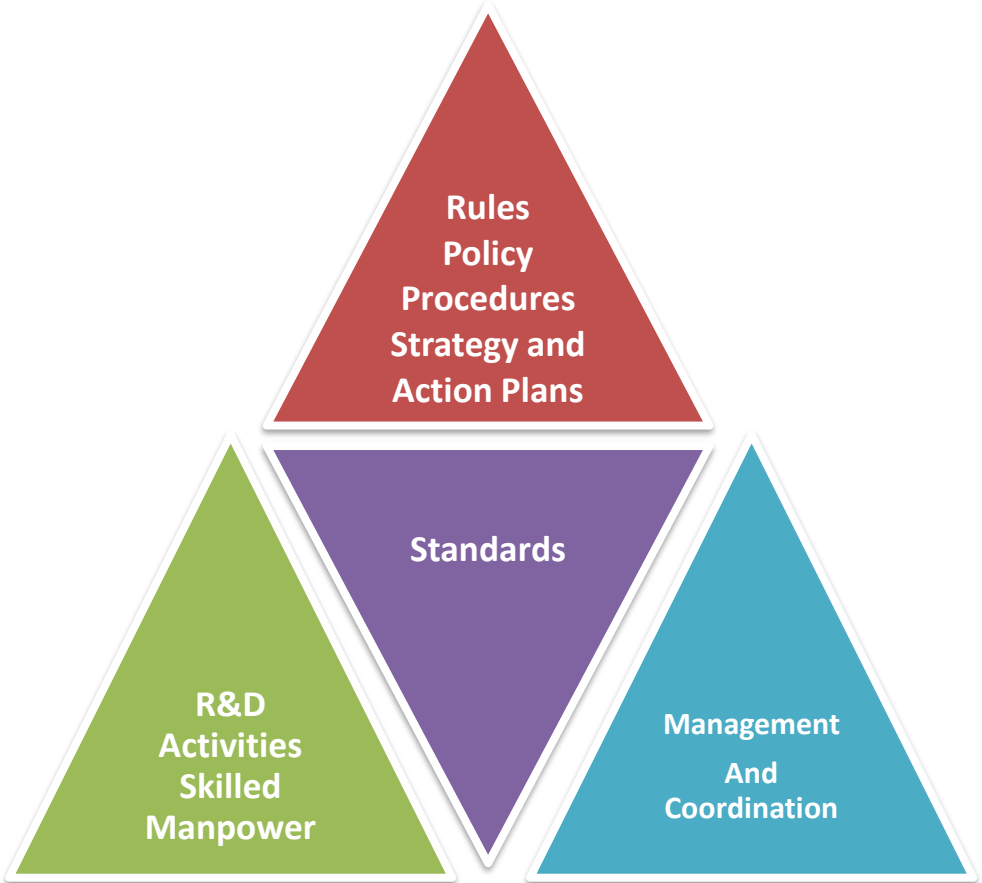
ATTACK SURFACE



Source: KASPERSKY

MATHS FOR CYBER SECURITY

CYBER SECURITY

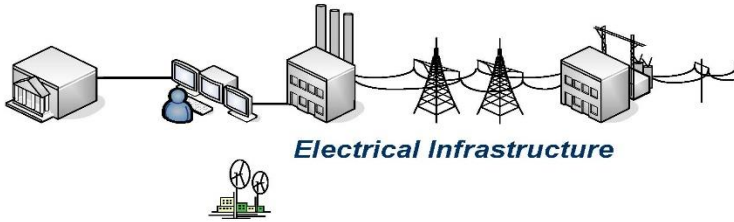


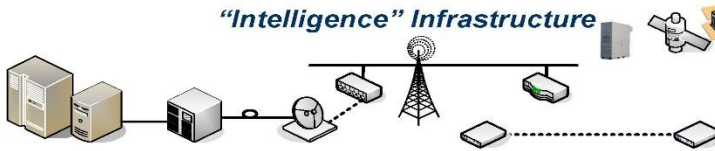
SMART GRID CYBER SECURITY

- Power Grid
  - Huge, critical, high-cost infrastructure
- ICT based systems
  - real-time monitoring
  - communication, processing, storage,
  - advanced analytics
  - fully automated systems (self-healing, AI based system)
  - also **vulnerable**

SMART GRID VULNERABILITIES

- Personal/enterprise information assets
- Vulnerable, under attack
- Target
- Not secure
- Privacy violation possible
- **Require protection**
- **Support privacy**

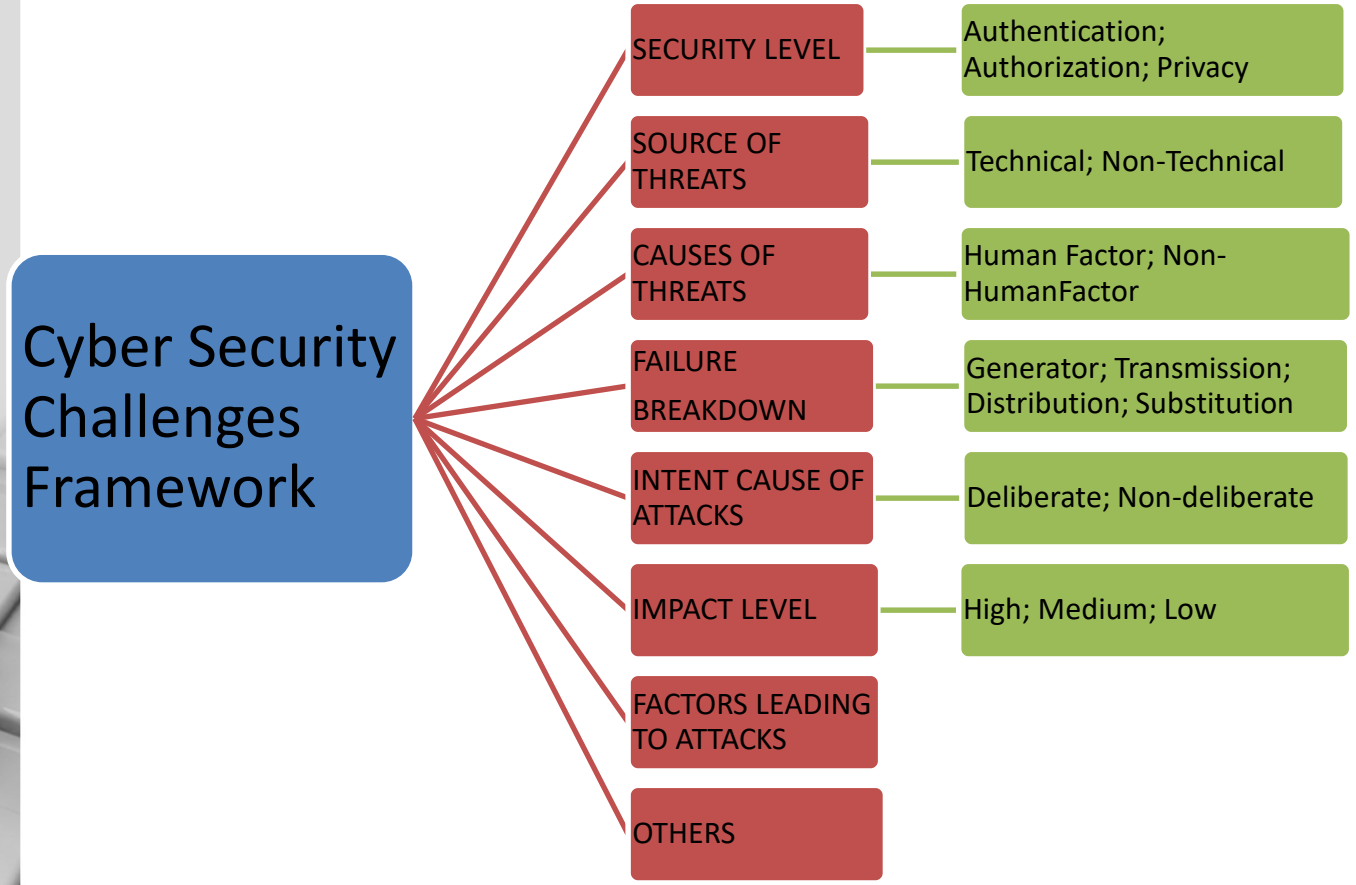


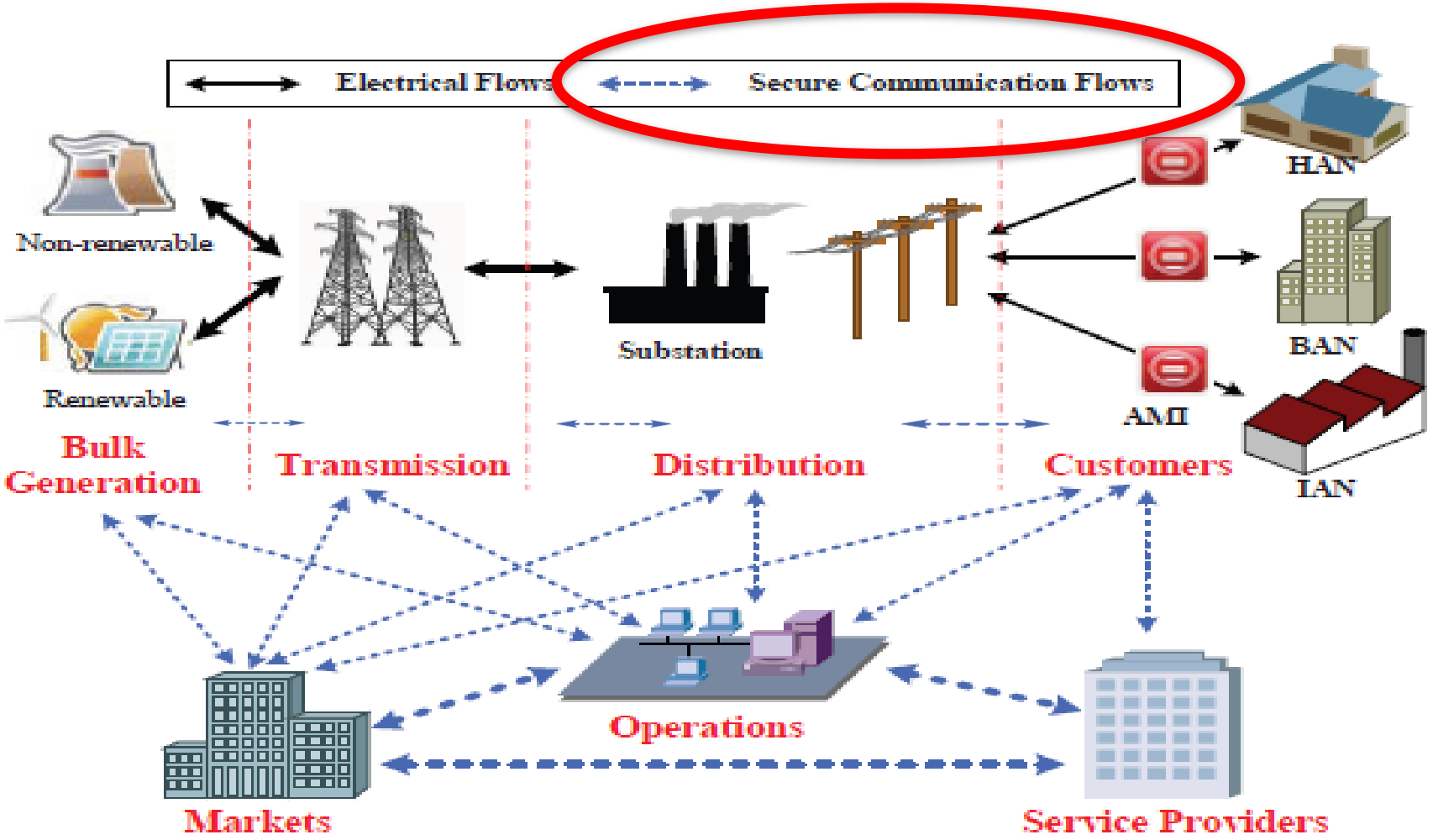


PRIORITY AREAS (NIST)

— Demand Response and Consumer Energy Efficiency
— Transportation Electrification
— Renewable Power Generation
— Energy Storage
— Advanced Metering Infrastructure
— Distributed Grid Management
— Wide-Area Situational Awareness
— Network Communications
— **Cyber Security**

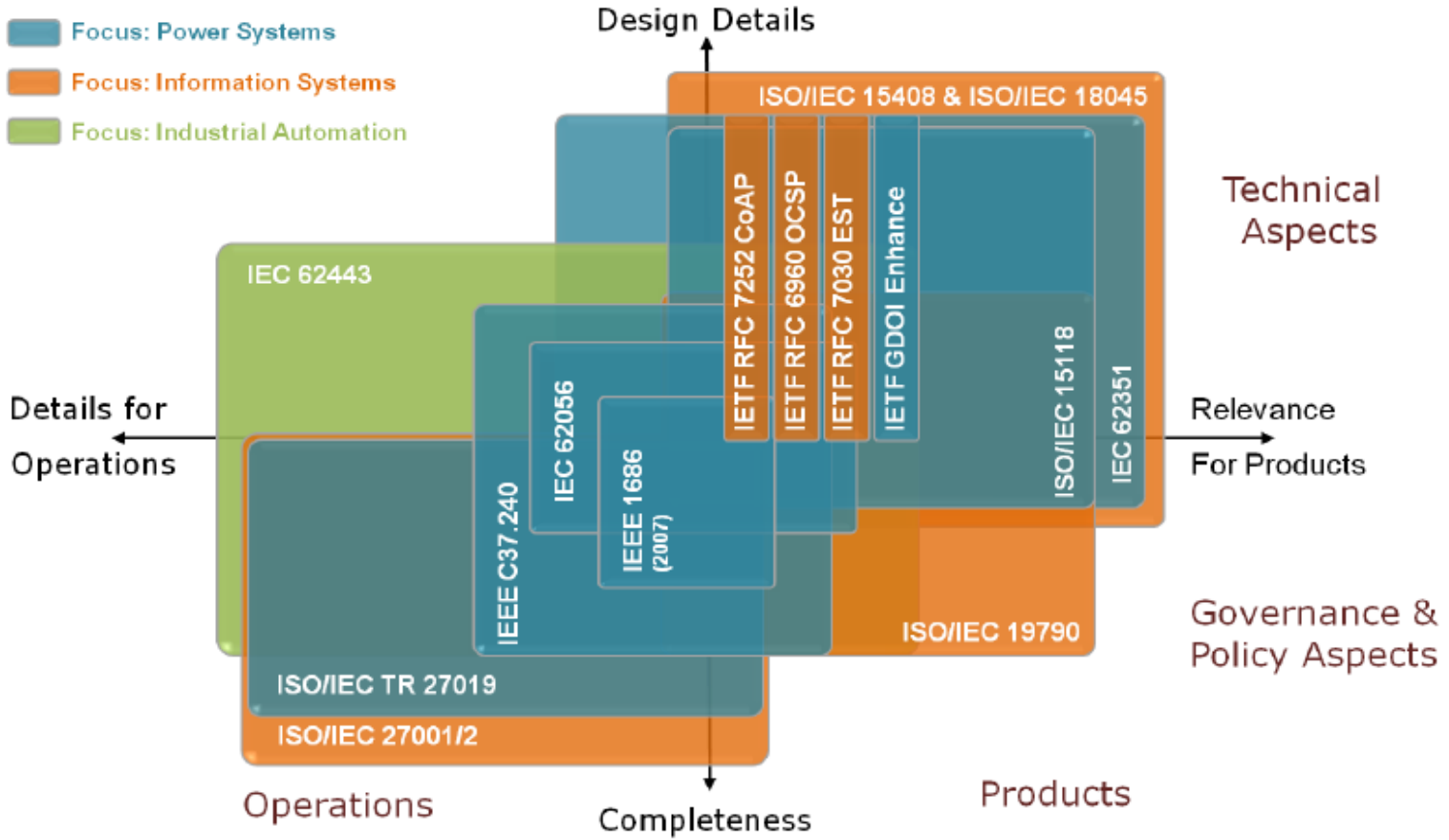
VULNERABILITIES CLASSIFICATION





Source: NIST reference model for the smart grid

SG CYBER SECURITY STANDARDS



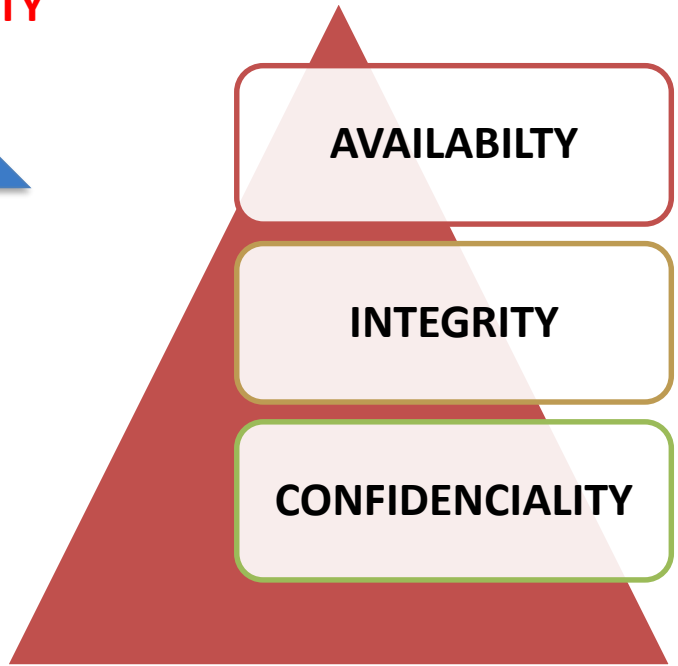
Source: https://www.cenelec.eu/aboutcenelec/whatwedo/technologysectors/smartgrids.html

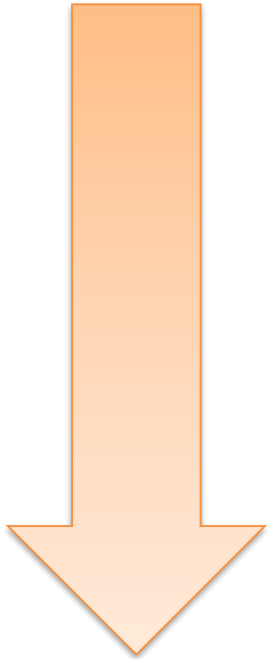
CYBER SECURITY CONCERNS

CONFIDENTIALITY	SECURITY & PRIVACY CONCERN FOR COMSUMERS
INTEGRITY	HACKING AND CHANGING DATA IN DEVICES AND SYSTEMS
AVAILABILITY	TAKING CONTROL OF DEVICES, NETWORKS AND SYSTEMS

CYBER SECURITY CONCERNS

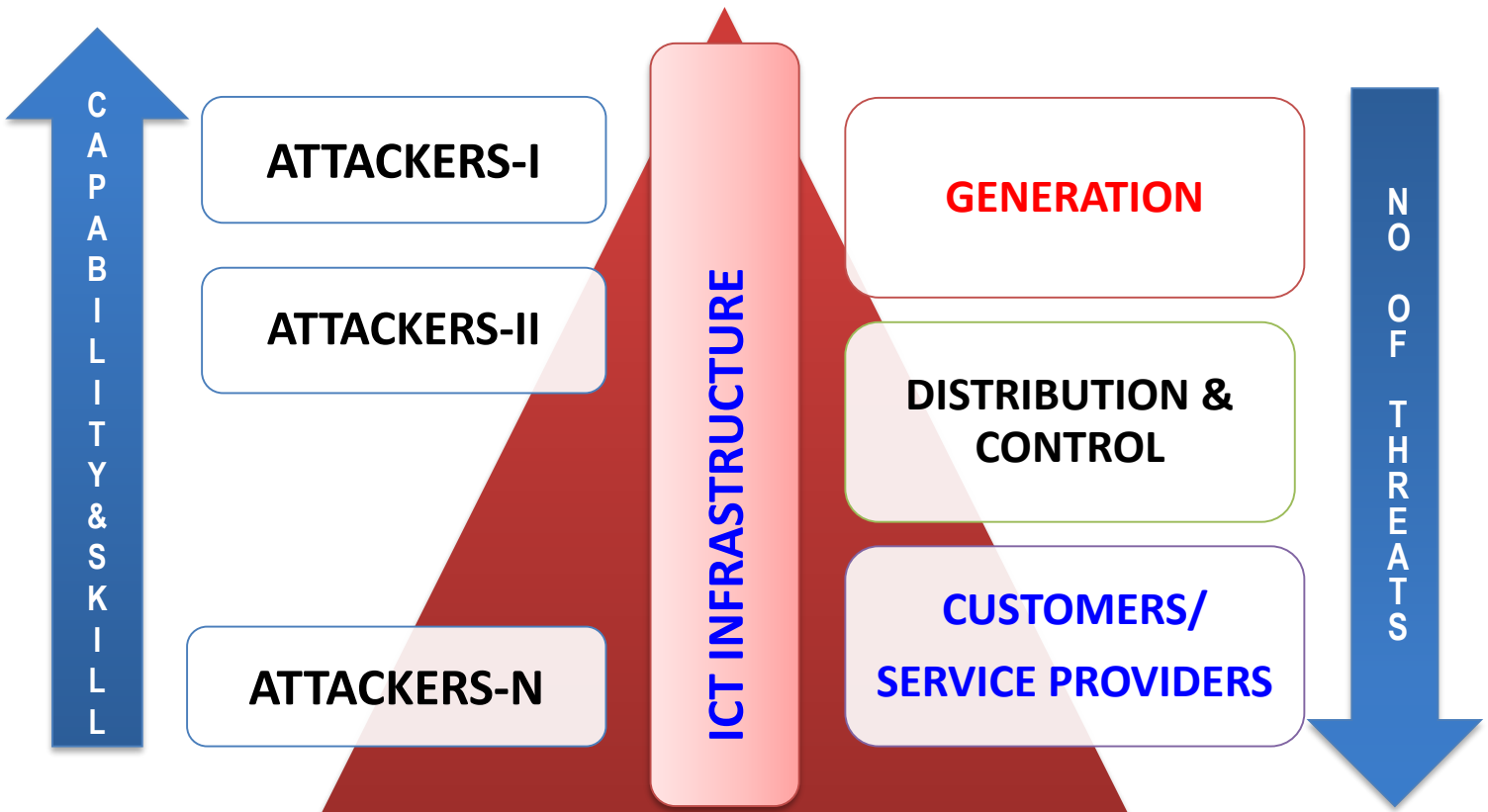
SERVICE QUALITY



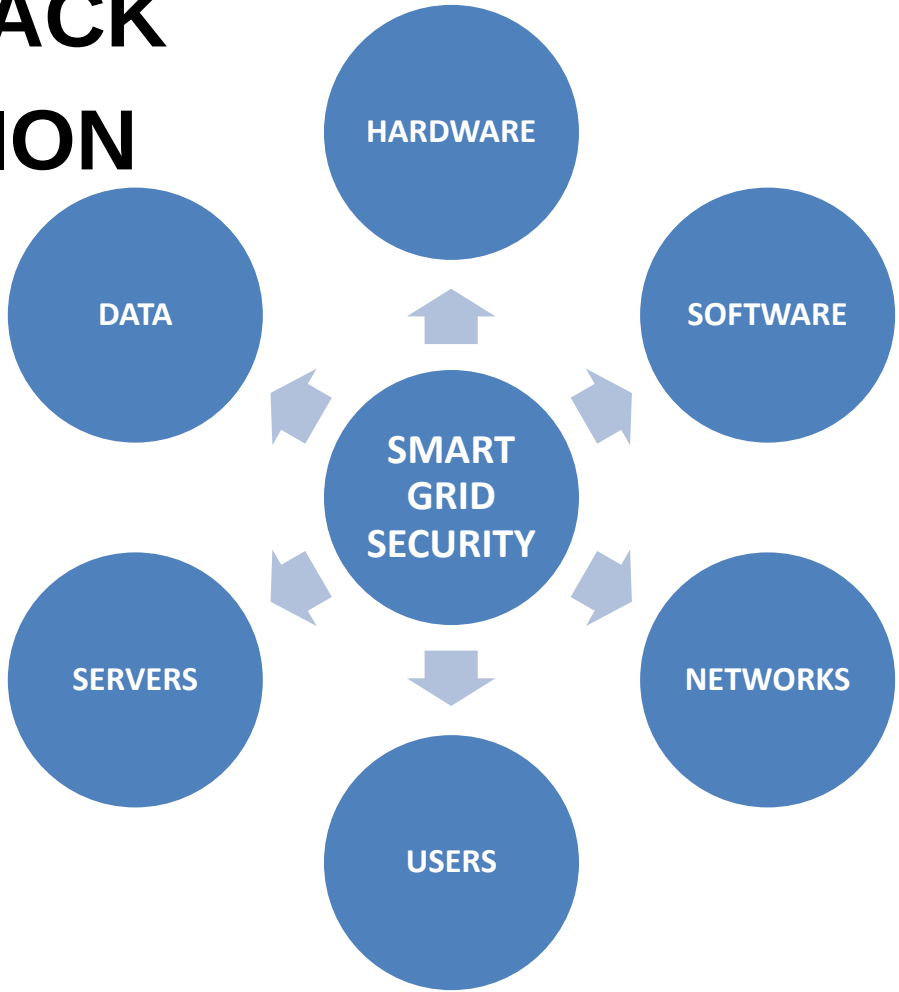


SECURITY
& PRIVACY

CYBER SECURITY CONCERNS



THREAT&ATTACK CLASSIFICATION



Source: Sagiroglu et al. IJRER No.4. 2019

TYPE OF VULNERABILITIES (Threats/Attacks)

Type of Threat/Attack
Tampering
Replay
Eavesdropping
Network monitoring, discovery and analysis
DoS
Spoofing
Intrusion attacks
Insider attack
Man in the middle
Viruses, Spyware, Trojans and Worms
Origin Disguise
Theft
Trapdoor
Keylogging

Type of Threat/Attack
Resource Exhaustion
Phishing
XSS
Operating system command injection
Path traversal
Web compromise
Buffer overflow
Physical intrusion
Information disclosure
Social engineering attacks
User compromise
Root compromise

CONCLUSION EVALUATIONS

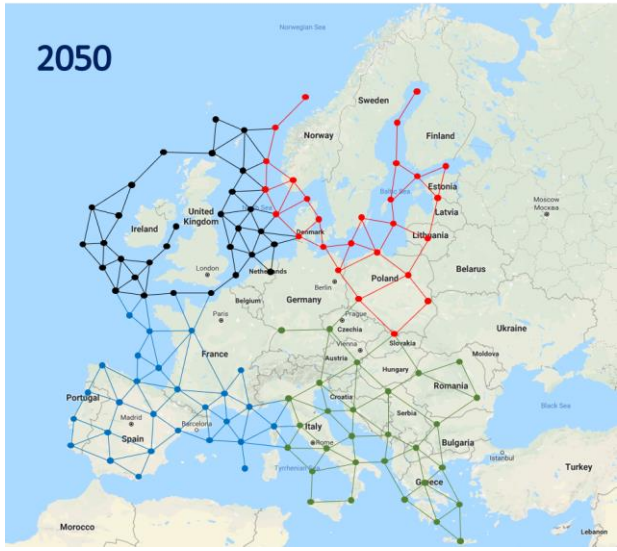
SUPPORTING SMART GRID

BEYOND

Smart Grid

Super Grid

Intelligent and Secure Super Grid



CHALLENGES IN SMART GRID SYSTEMS

- Providing **high quality service**
- **Cost effective** operation
- Developing **better and faster** solutions to problems
- Managing network effeciently, securely, optimally, intelligently
- **Security and Privacy**
- **Gaining new values from information assets**

CONCLUSIONS - 1

- **Big Data Analytics, Data analytics**
- **develop new solutions** for designing and developing better SG systems and services
- new **improved services** for customers & operators
- manage systems **intelligently, effectively and securely**
- reduce **cost**
- **Plan better and handle** to predict demands

CONCLUSIONS - 2

- **handling data properly** might be an opportunity for consumers, operators, service providers, markets, industries
- **Data collection, integration, and sharing policies** among companies, institutions, government unit are important
- companies and governments can **benefit** from BDA not only for SG but also other industrial best practices.

CONCLUSIONS - 3

- **data-driven solutions** can be achieved for energy awareness, green&renewable energy, SG, electric power systems, etc. using BDA
- **Support EU Green Deal Agreement**
- **Improve perspective** not only for security & privacy issues but also other issues
- Cloud systems are required

CONCLUSIONS - 4

- IEEE, ITU, NIST, ISO, CENELEC provide plausible solutions to secure SGs
- Violations increase, but also solutions
  - AI, DL, and ML models provide better solutions but also bring new problems
  - Attacks on DL, AI, and ML models possible
  - require quality of data for better modeling
  - GDPR, DPA, or National DPR issues
  - Privacy-Preserving Big Data Publishing
  - Differential Privacy Solutions

Q&A

Prof. Dr. Seref SAGIROGLU
ss@gazi.edu.tr