Multi-Model Based Incident Prediction and Risk Assessment in Dynamic Cybersecurity Protection for Industrial Control Systems

Zhang Qi

zqmillet@hust.edu.cn

October 7, 2015

Automation School,
Huazhong University of Science and Technology,
Wuhan.

Outlines

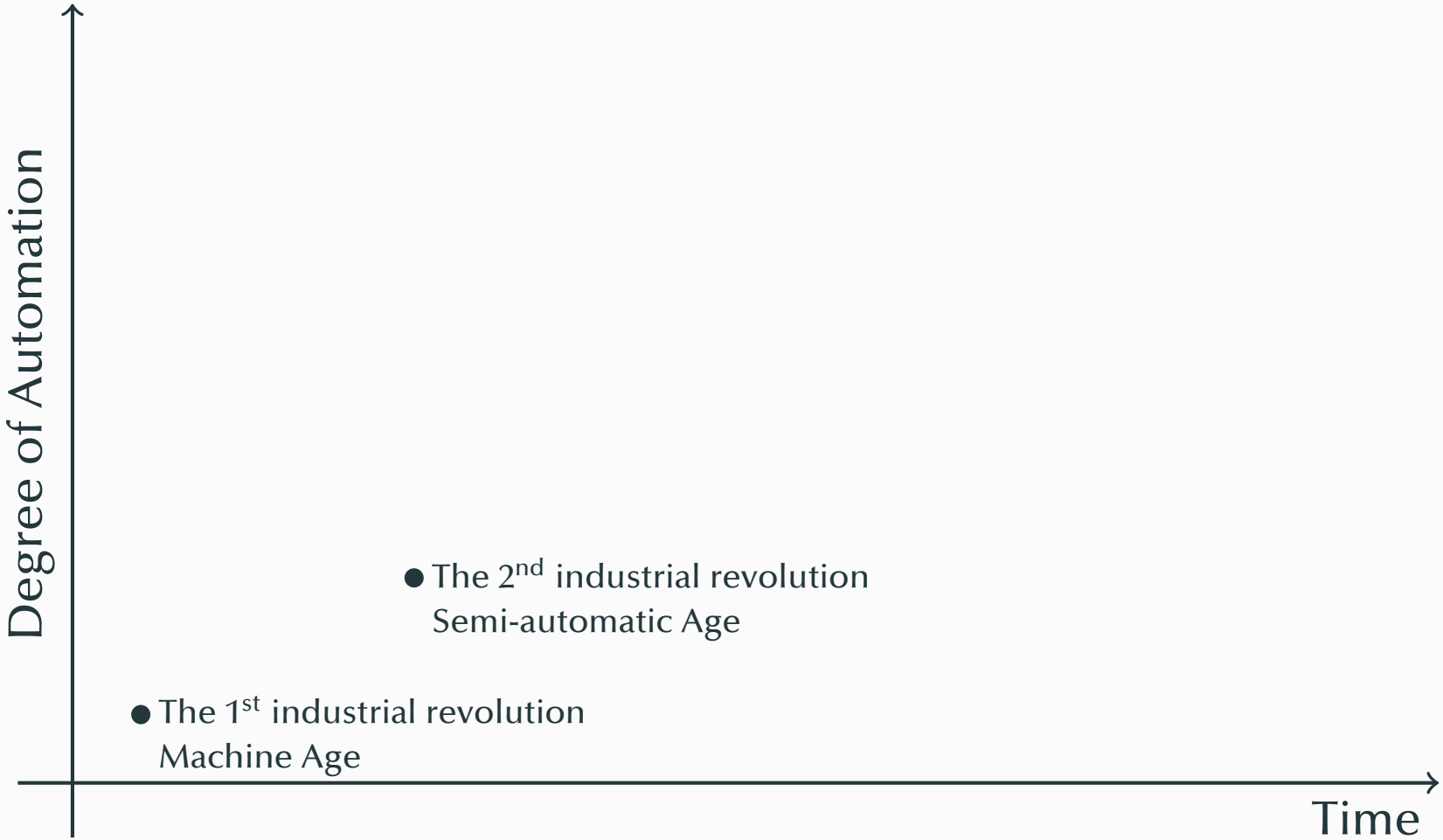
Introduction

Background

Driven by computer technology, communication technology and intellectual technology, Industrial Control Systems (ICSs) develop towards the direction of intellectualization and network.

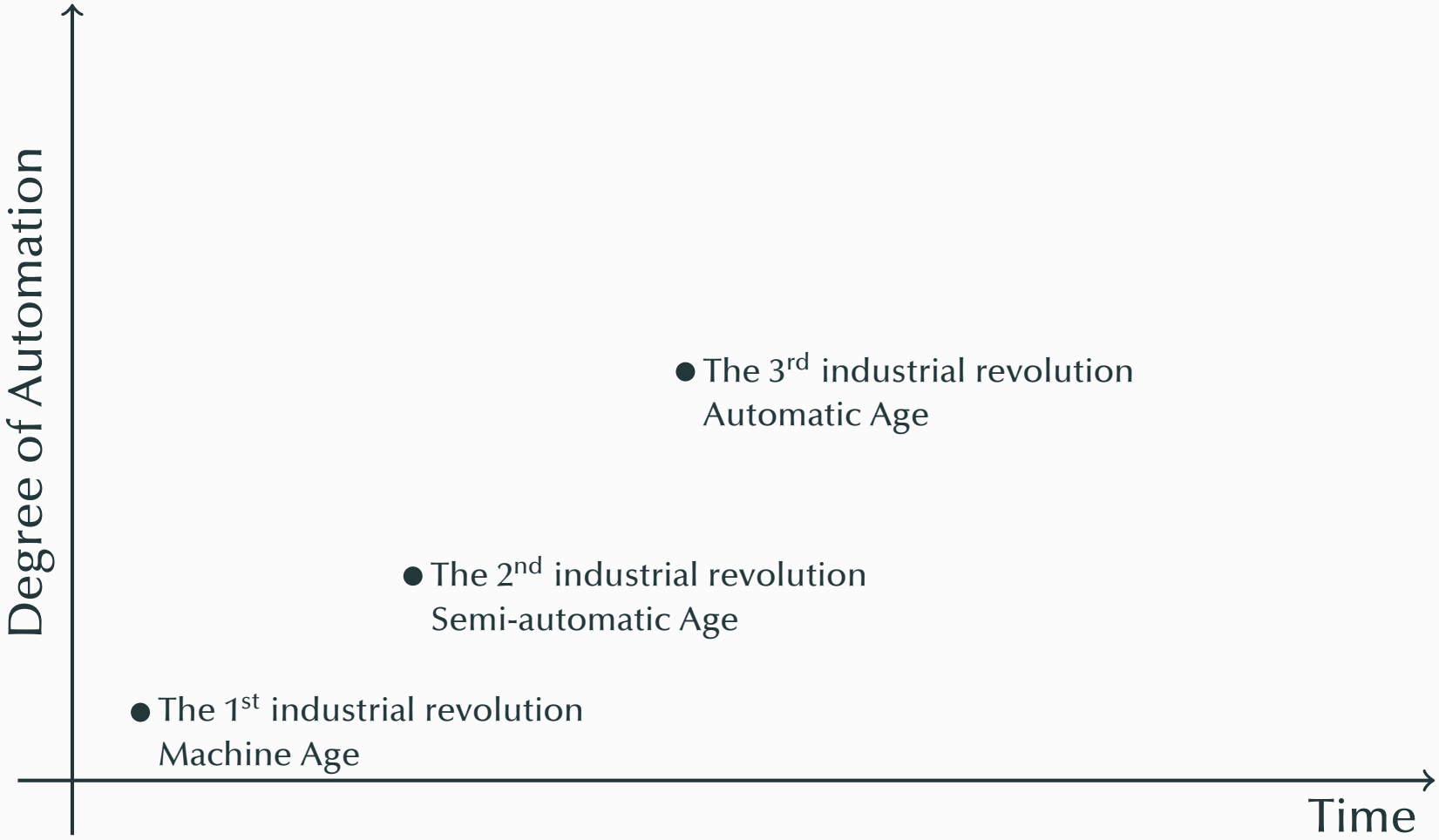
Background

Driven by computer technology, communication technology and intellectual technology, Industrial Control Systems (ICSs) develop towards the direction of intellectualization and network.



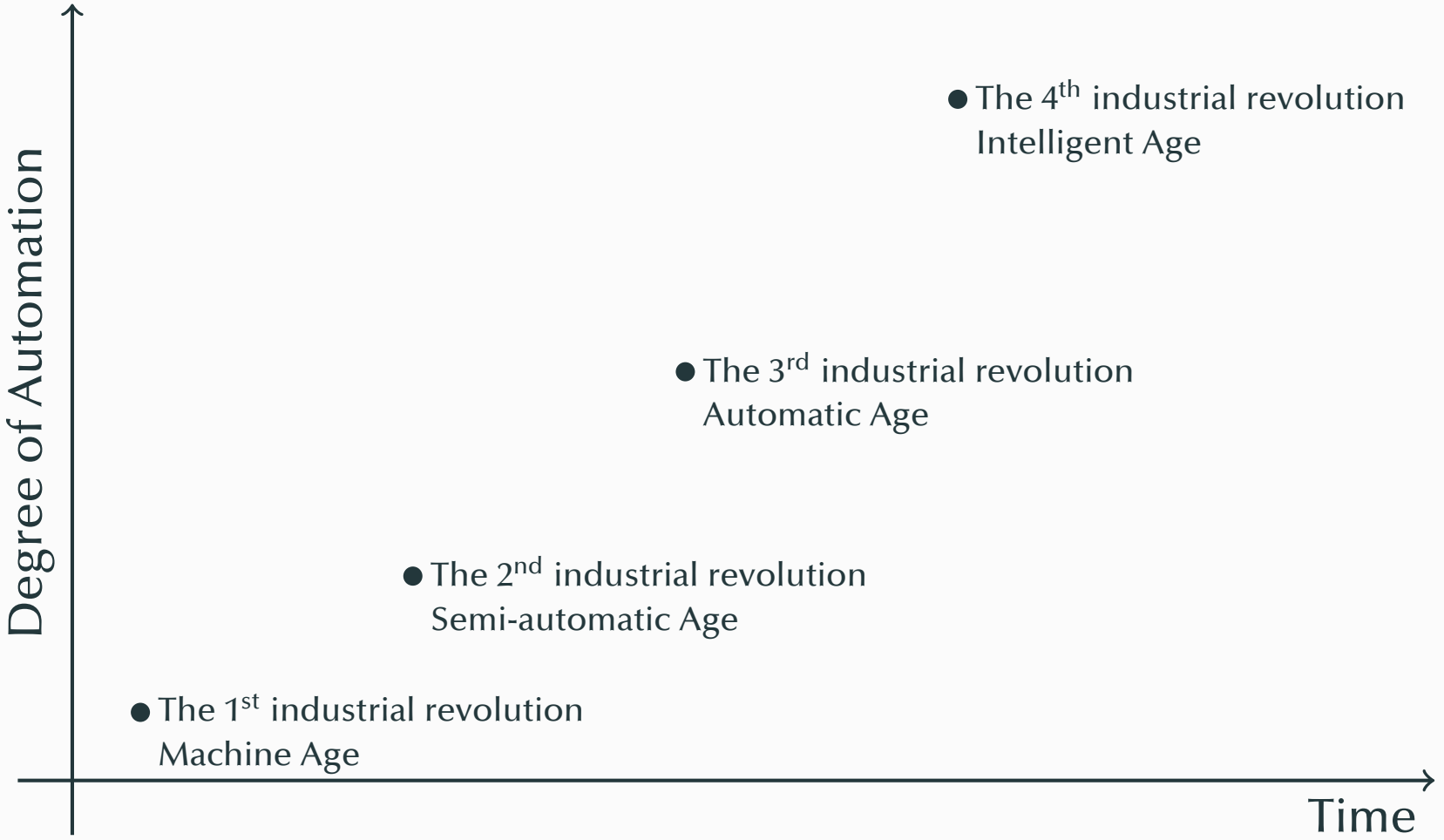
Background

Driven by computer technology, communication technology and intellectual technology, Industrial Control Systems (ICSs) develop towards the direction of intellectualization and network.



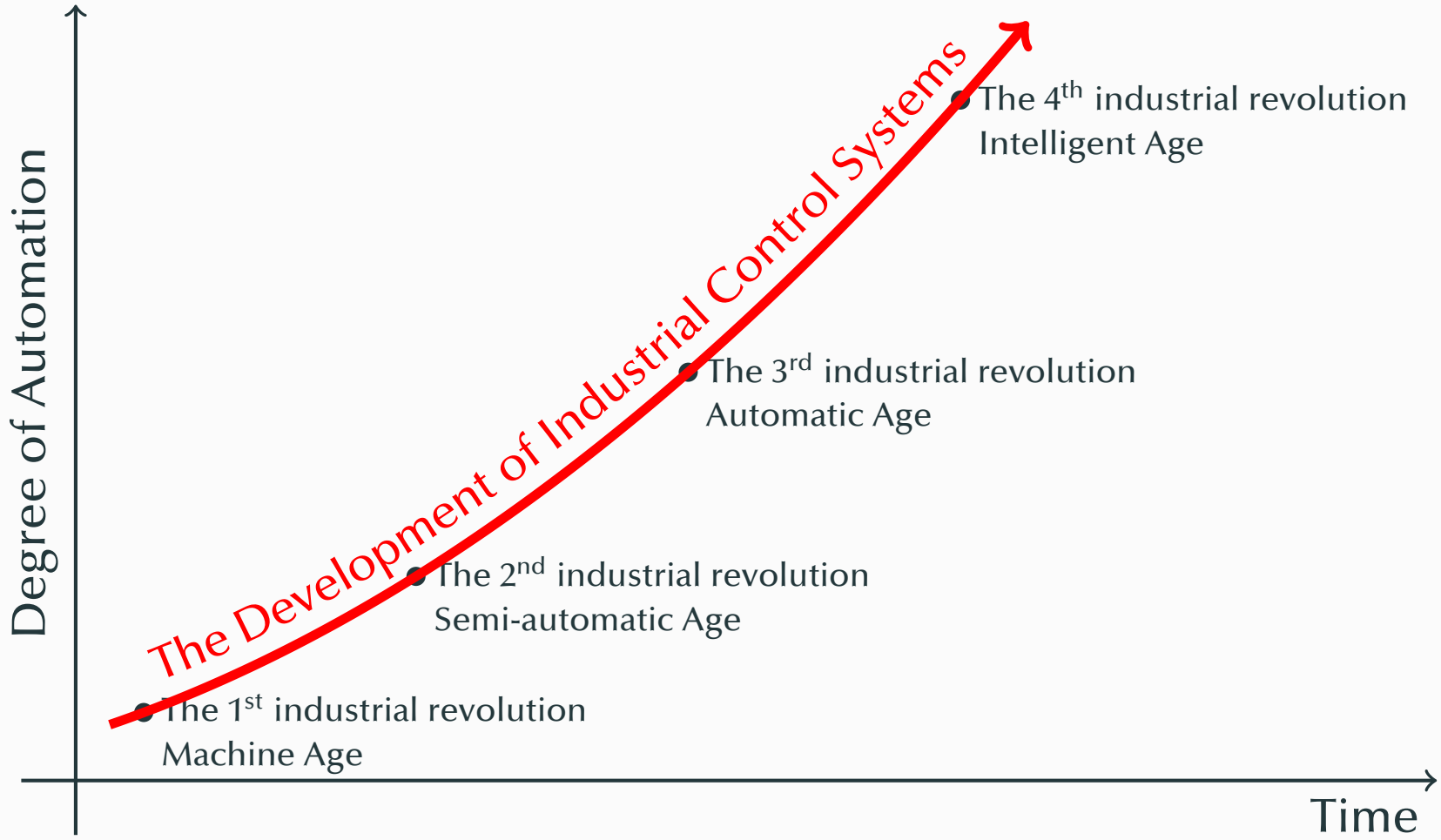
Background

Driven by computer technology, communication technology and intellectual technology, Industrial Control Systems (ICSs) develop towards the direction of intellectualization and network.



Background

Driven by computer technology, communication technology and intellectual technology, Industrial Control Systems (ICSs) develop towards the direction of intellectualization and network.

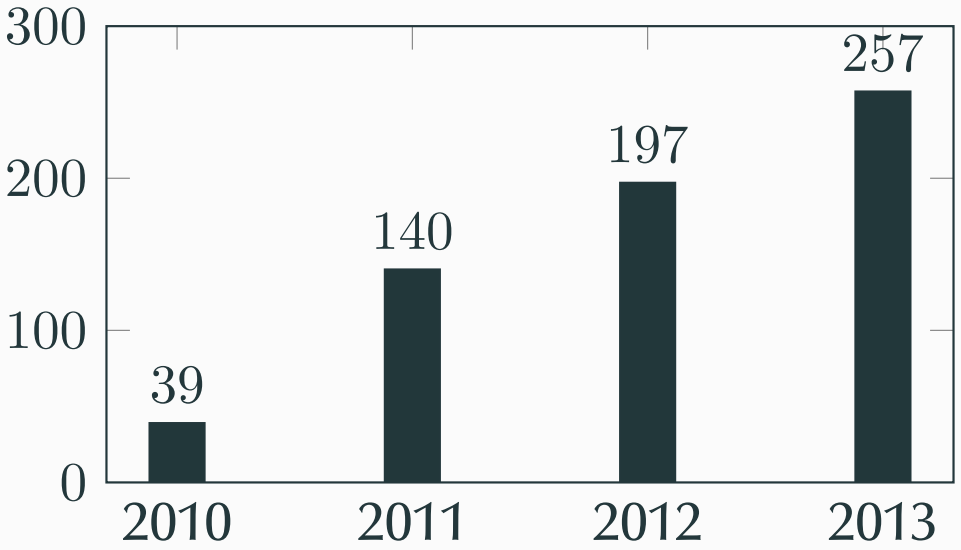


Background

- ICSs have been widely applied in various industry of the national economy and people's livelihood, and gradually become the brain and central nervous of critical infrastructure and all kinds of industrial production.
- Once abnormal situation appears in ICSs , serious accidents may be happen, which may cause damage to property, people or a wide range of environment.

Background

- In 2010, Stuxnet attacked Iran's nuclear power plants and ruined almost one-fifth of Iran's nuclear centrifuges.
- In 2013, Israel Haifa highway control system was attacked by hackers, which caused massive traffic congestion in the city which lead great loss and serious subsequent problems.
- In 2014, Havex malware infects many industrial control system in European and caused the leakage of large amounts of data.



ICSs Event Statistic (ICS-CERT)

Problems – Timeliness and Availability

ICSs have rigorous requirements on timeliness and availability. The cybersecurity risks of ICSs are primarily from the potential loss caused by the cyber-attacks which demolish the timeliness and availability of the control system.

In order to achieve the destructive purpose, attackers generally need to follow part or all of these three steps:

1. infiltrate into the field network,
2. invalidate the system functions,
3. cause the hazardous incidents.

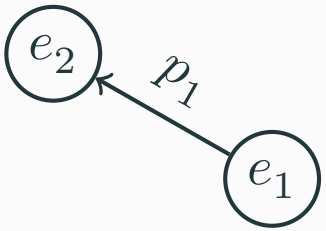
Therefore, the cybersecurity risk assessment of ICSs needs a novel and targeted risk model to analyze the risk propagation.

Problems – Overlapping amongst Consequences

The majority of existing quantitative risk assessment approaches used the following definition to calculate the risk $\mathcal{R}$.

$$\mathcal{R} = \sum_i S(e_i)P(e_i)$$

However, the overlapping amongst difference consequences may cause the error of risk value. For example,



incident e_1 is the temperature anomaly of reactor, incident e_2 is the explosion of reactor, when e_1 or e_2 happens, the product will be damaged.

Assume that $P(e_1) = 1$, so $P(e_2) = p_1$, then

$$\mathcal{R} = S(e_1) + p_1 S(e_2) = S(e_1) + p_1 S(e_1) = (1 + p_1)S(e_1) \geq S(e_1).$$

Problems – Unknown Attacks

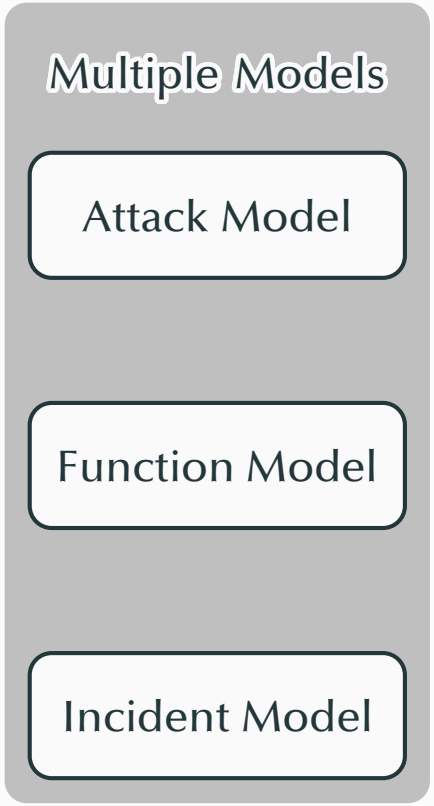
Many ICSs run 24/7/365, and therefore the updates must be planned and scheduled days or weeks in advance. After the updates, exhaustive testing is necessary to ensure the high availability of the ICS.

This leads to inability of the attack knowledge of ICSs to be updated in time. Several attack knowledge-based risk assessments cannot work well on ICSs.

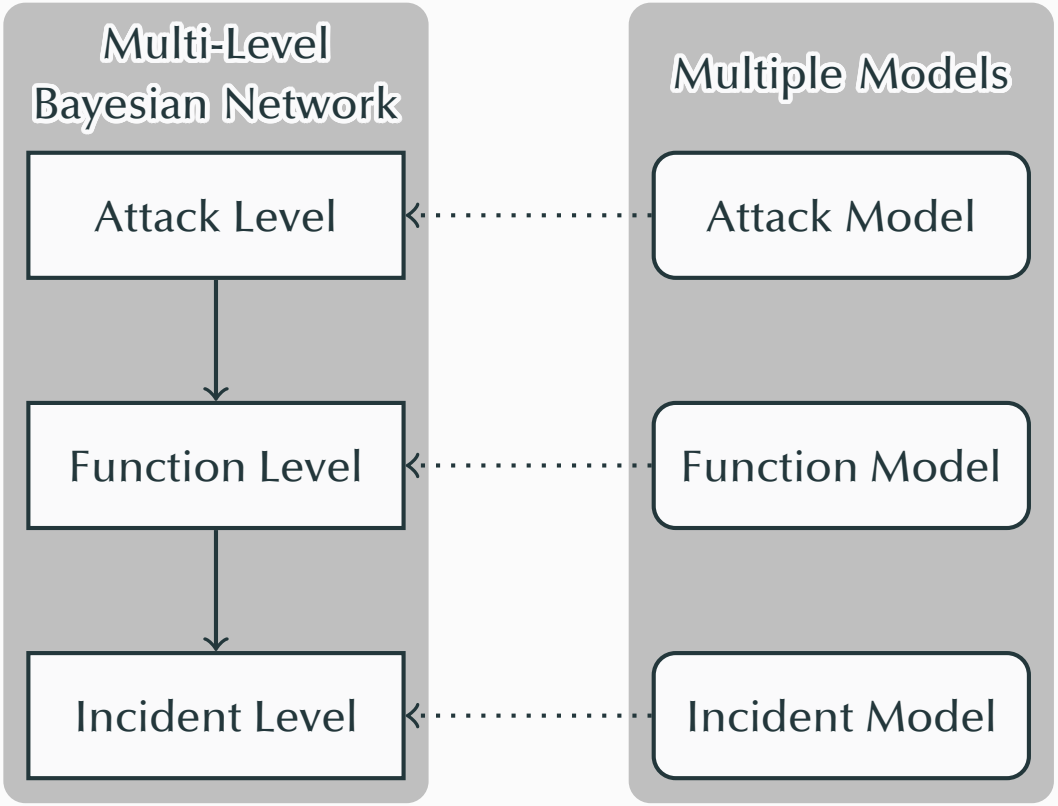
Therefore, the risk assessment should have the ability of assessing the risk caused by unknown attacks without the corresponding attack knowledge.

Architecture

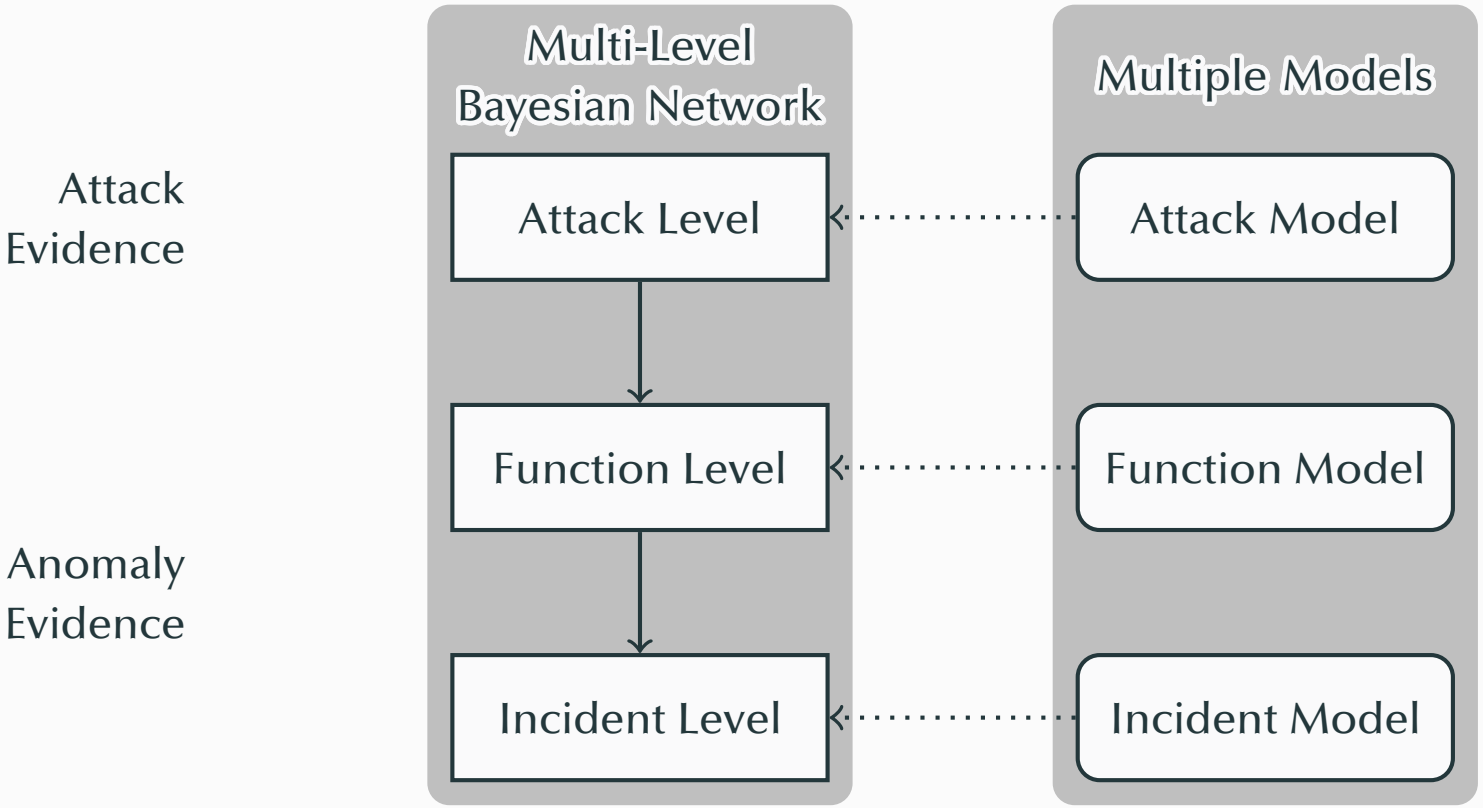
Architecture of Cybersecurity Risk Assessment for ICSs



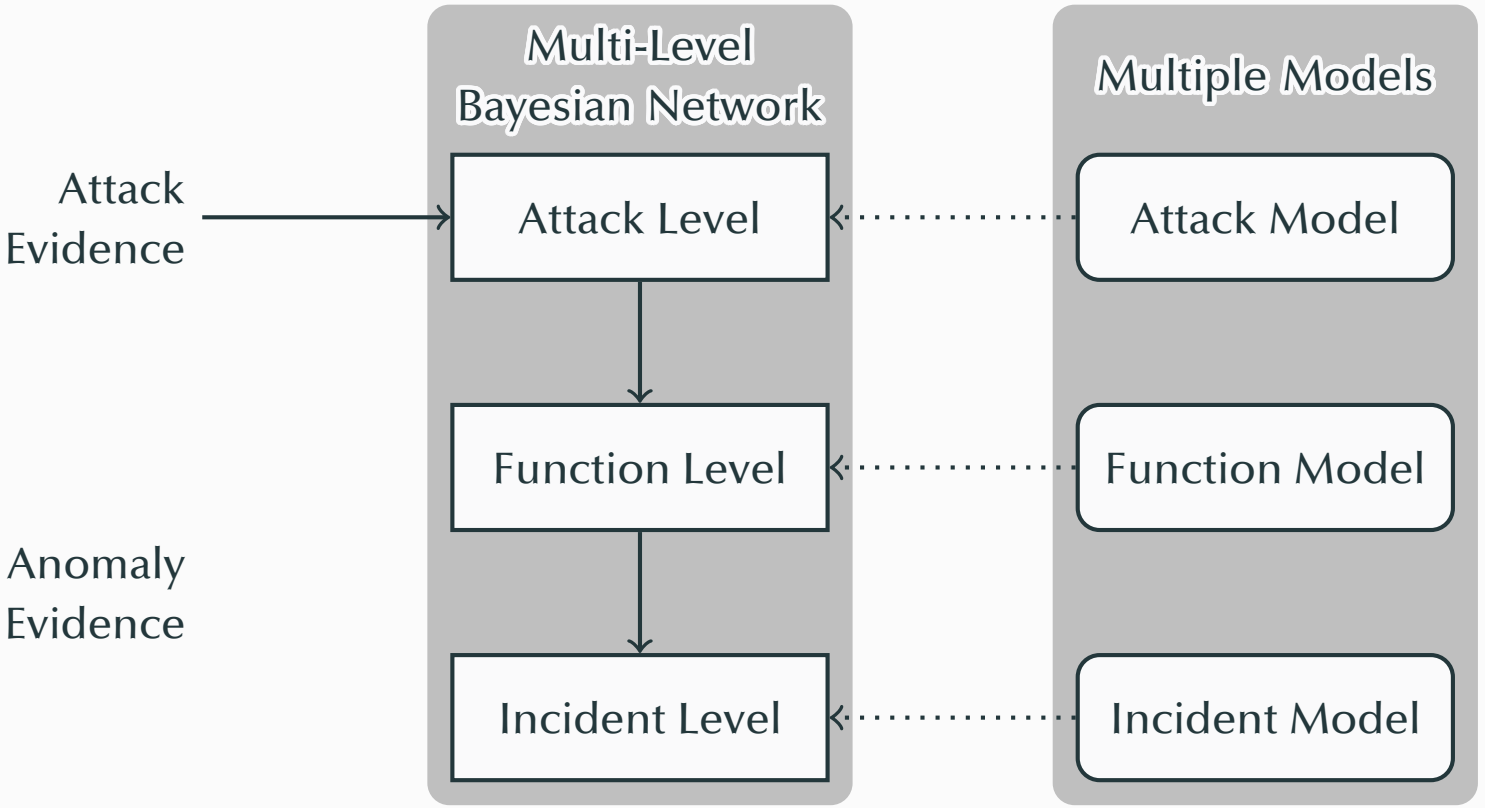
Architecture of Cybersecurity Risk Assessment for ICSs



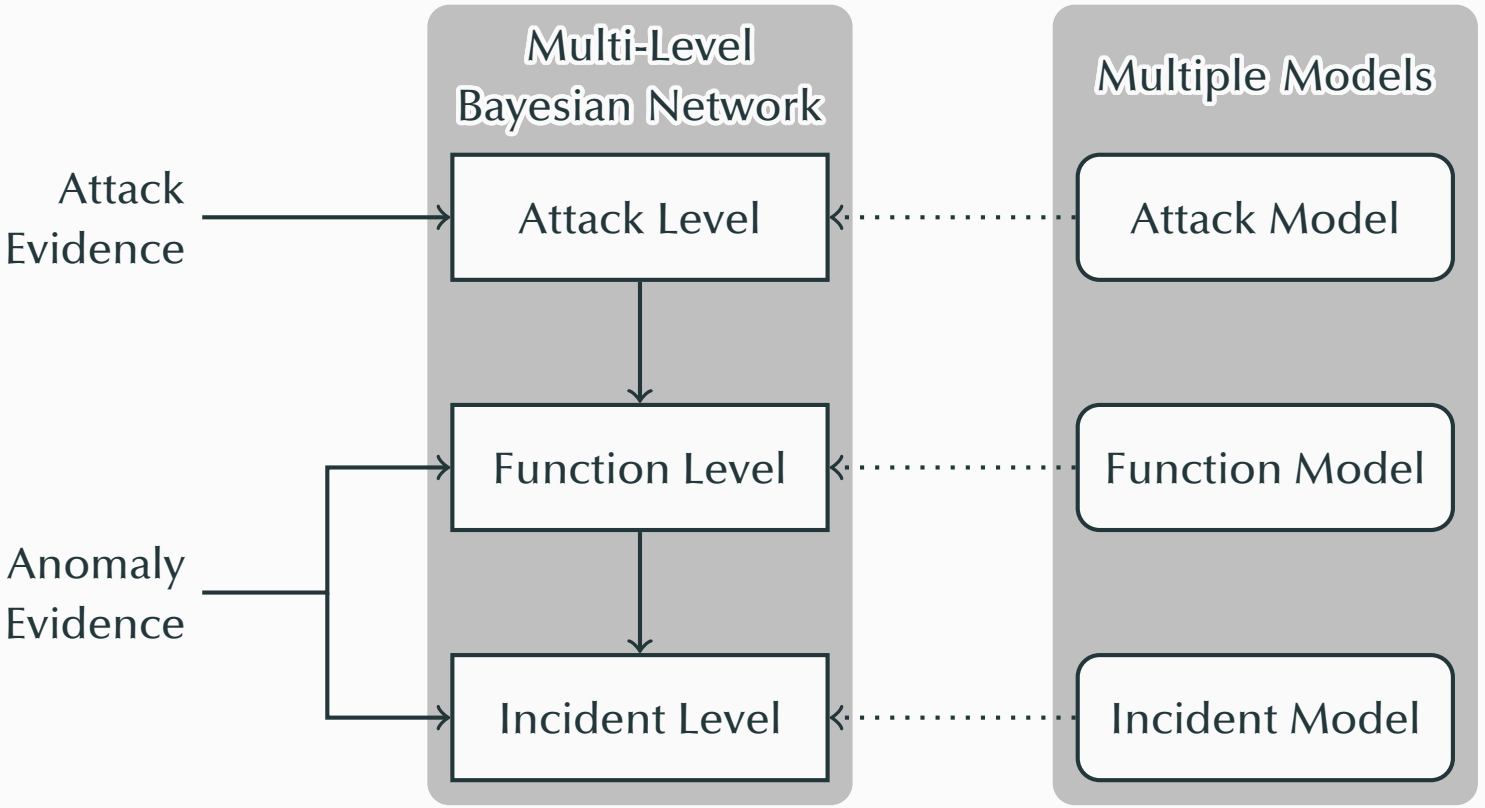
Architecture of Cybersecurity Risk Assessment for ICSs



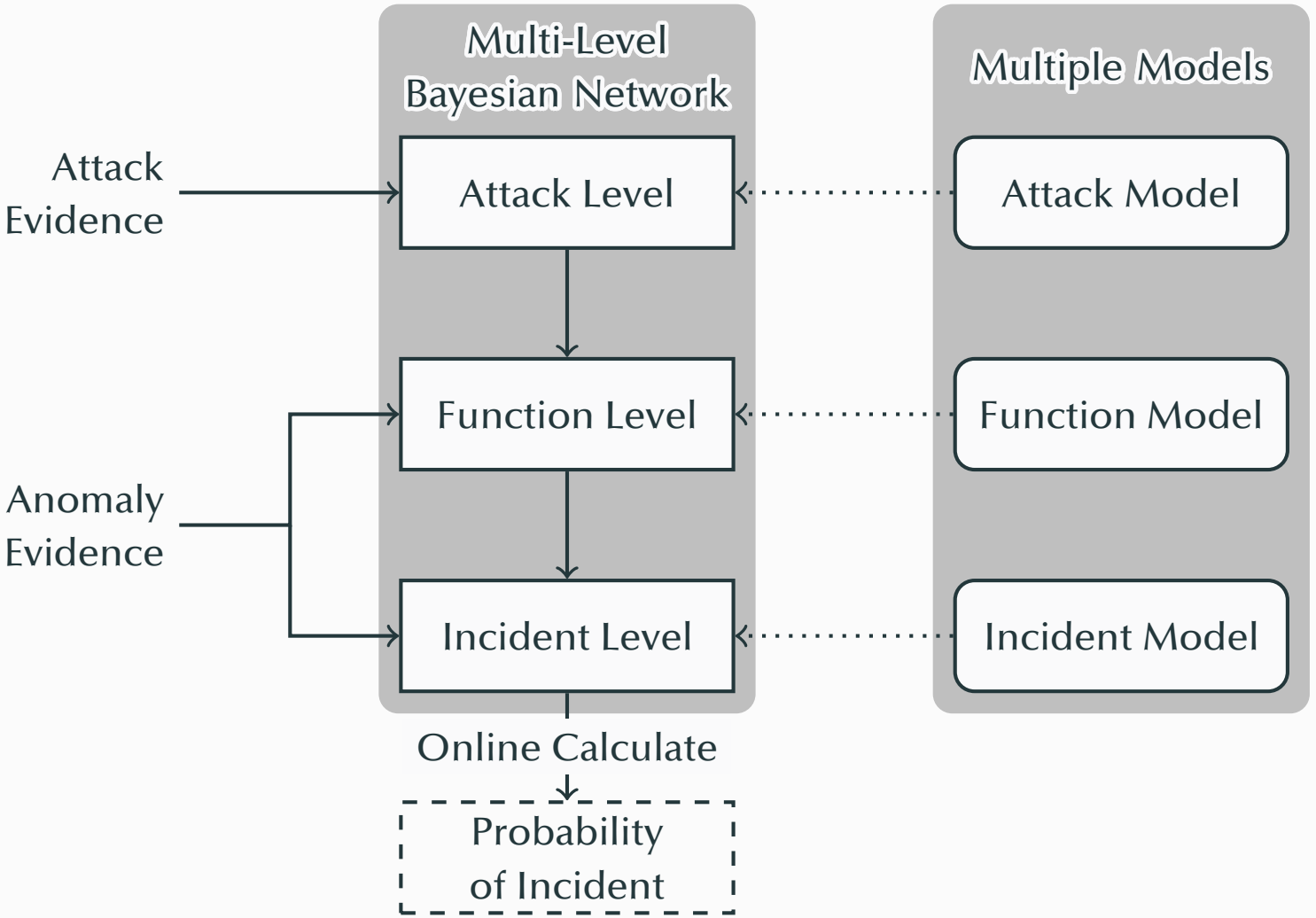
Architecture of Cybersecurity Risk Assessment for ICSs



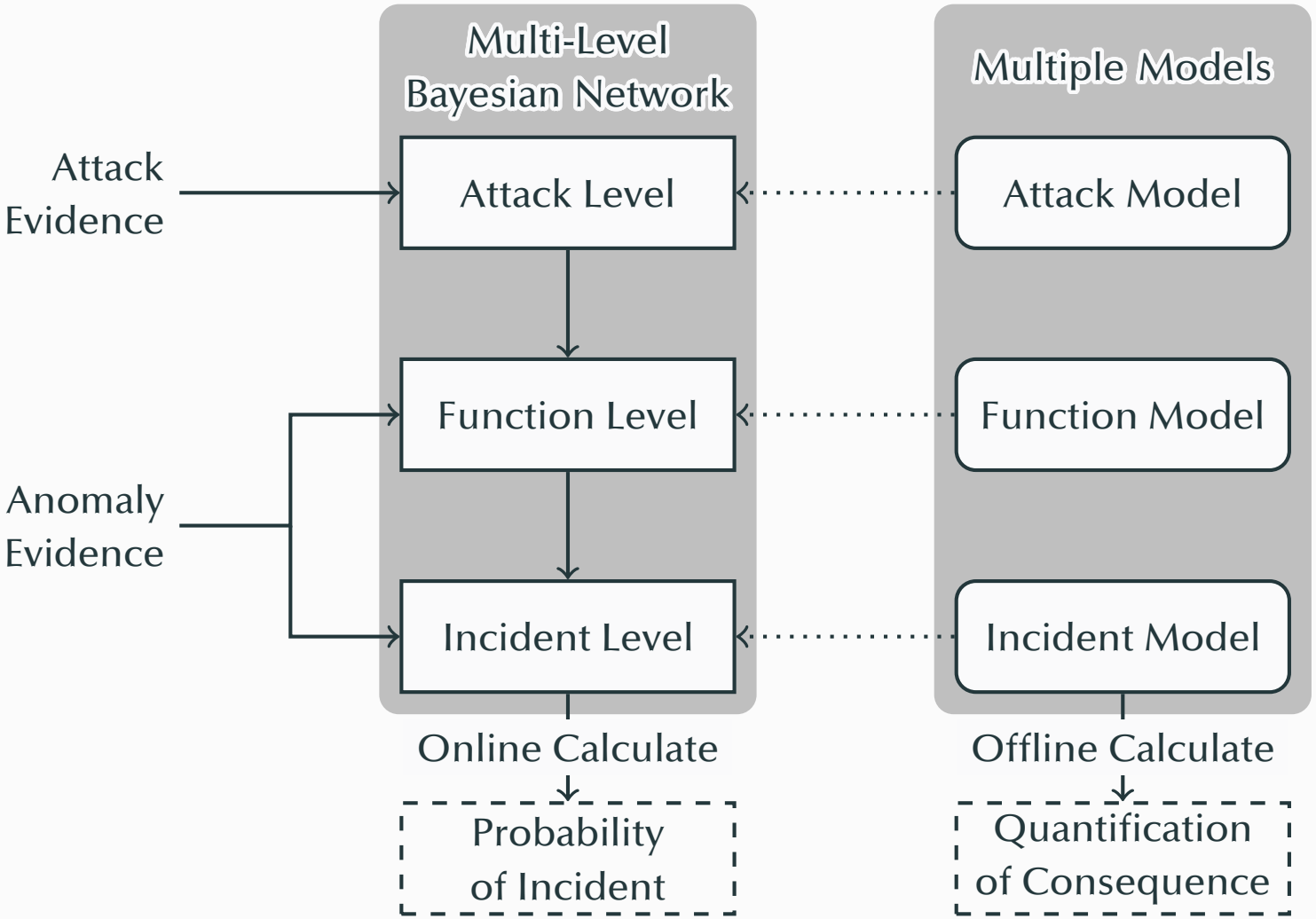
Architecture of Cybersecurity Risk Assessment for ICSs



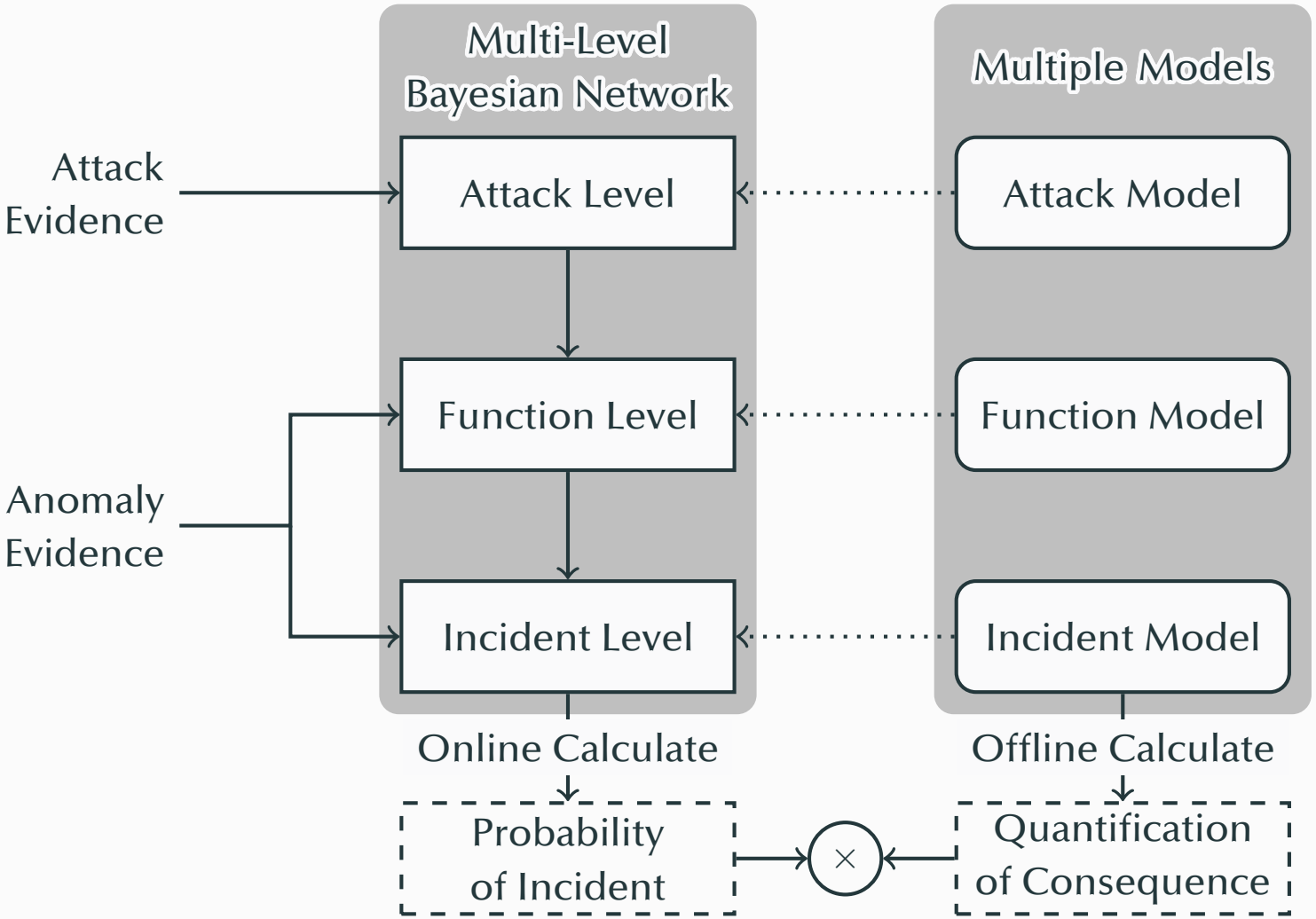
Architecture of Cybersecurity Risk Assessment for ICSs



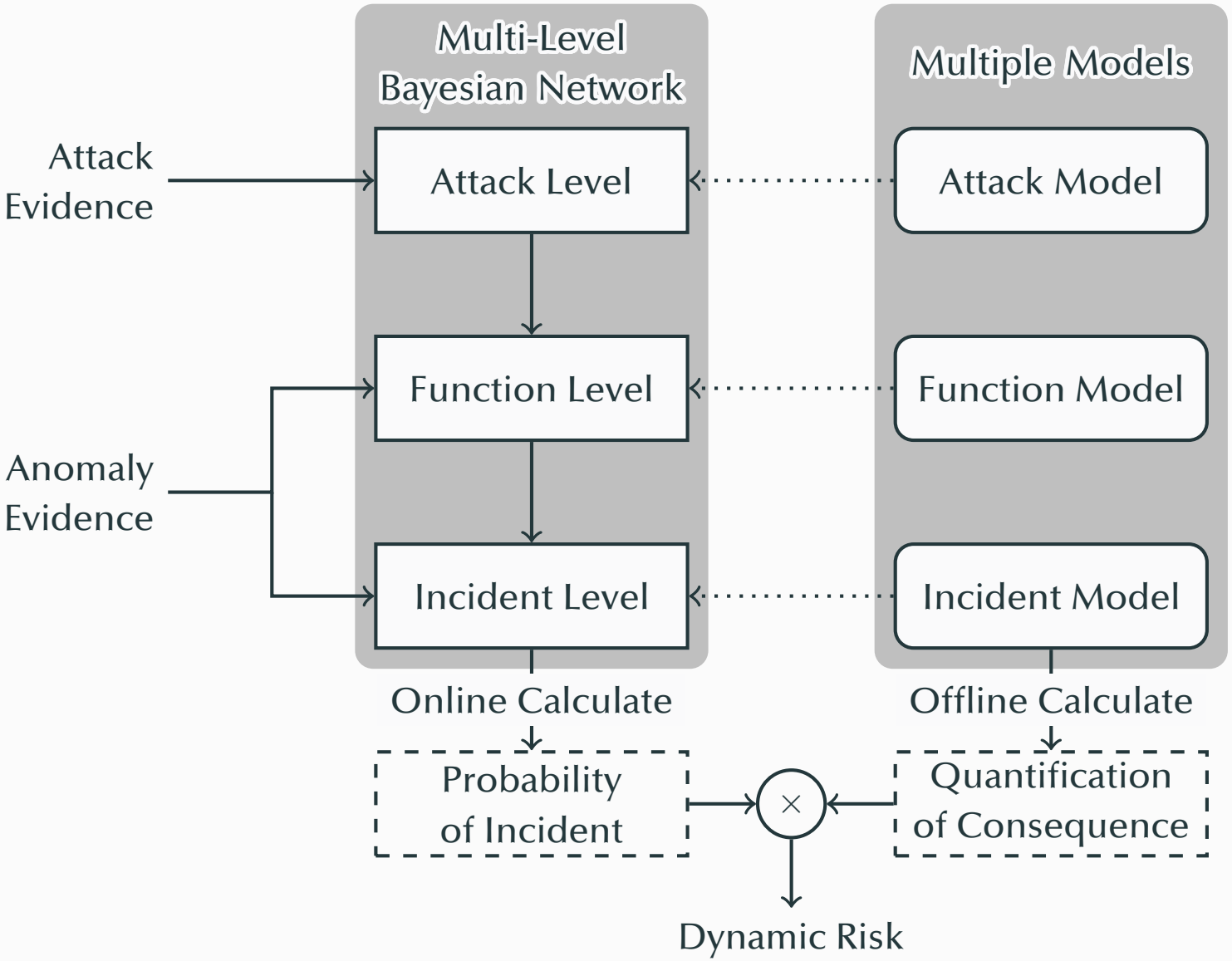
Architecture of Cybersecurity Risk Assessment for ICSs



Architecture of Cybersecurity Risk Assessment for ICSs



Architecture of Cybersecurity Risk Assessment for ICSs



Hazardous Incident Prediction

Attack Level

Function Level

Incident Level

Collection of Evidence

Calculation of Incident Probability

Dynamic Risk Assessment

Harm to Humans

Environmental Pollution

Property Loss

Quantification of Harm to Humans

Quantification of Environmental Pollution

Quantification of Property Loss

Calculation of Dynamic Risk

Simulation

Knowledge Modeling and Simulation Platform

Simulation and Result Analysis

Questions?