Adaptive and composite privacy and security mechanism for IoT communication

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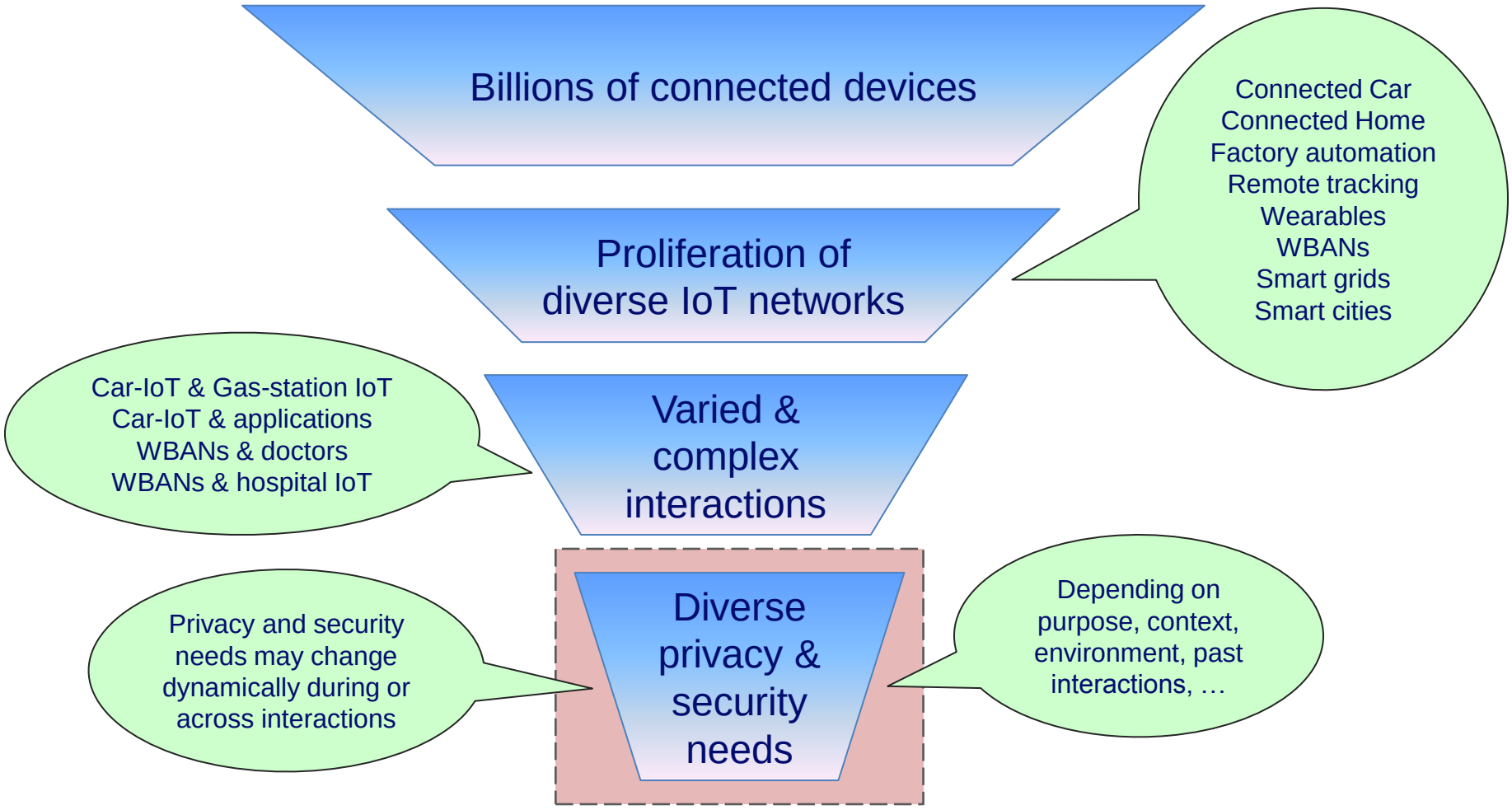
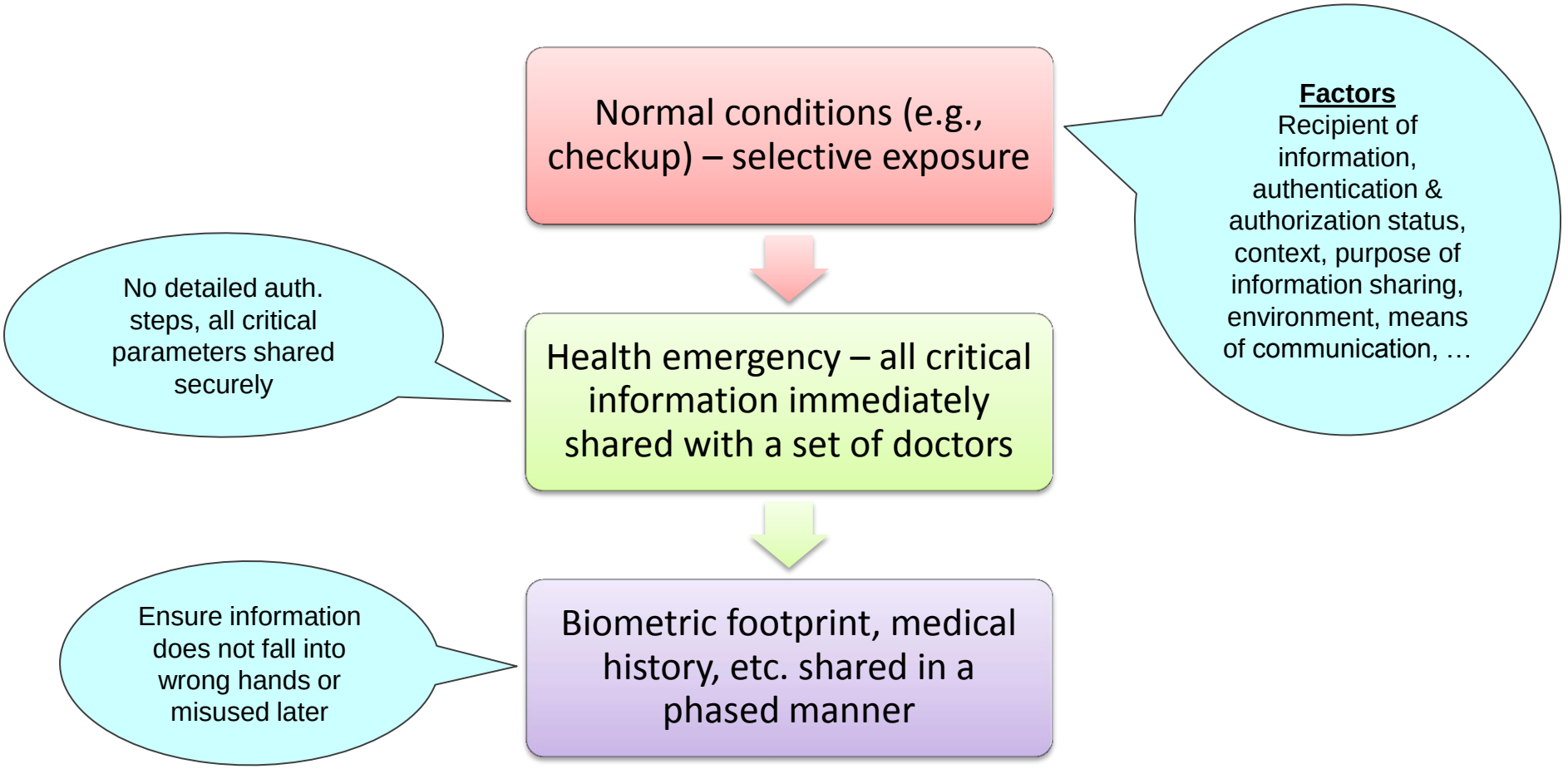
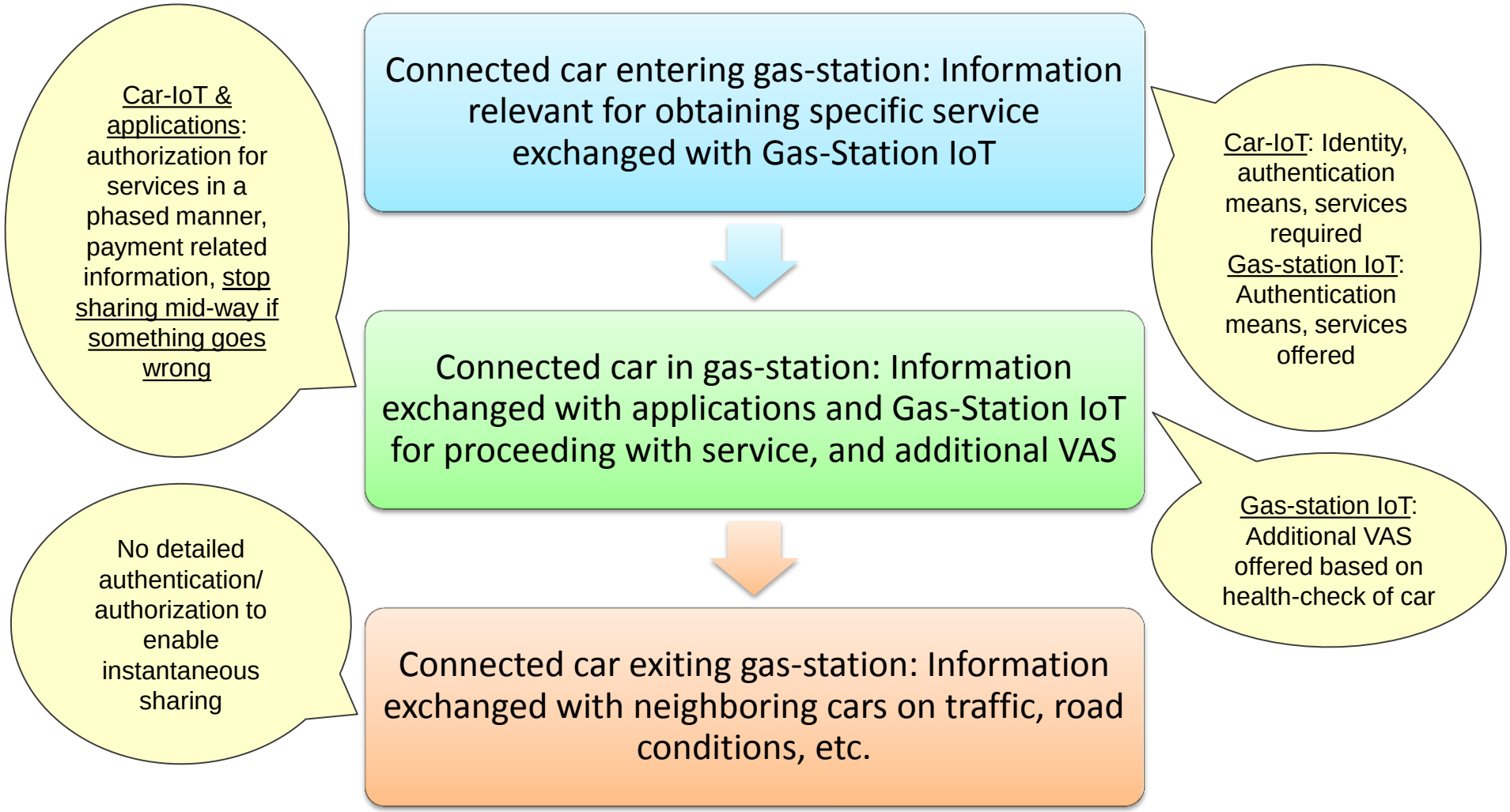
Introduction



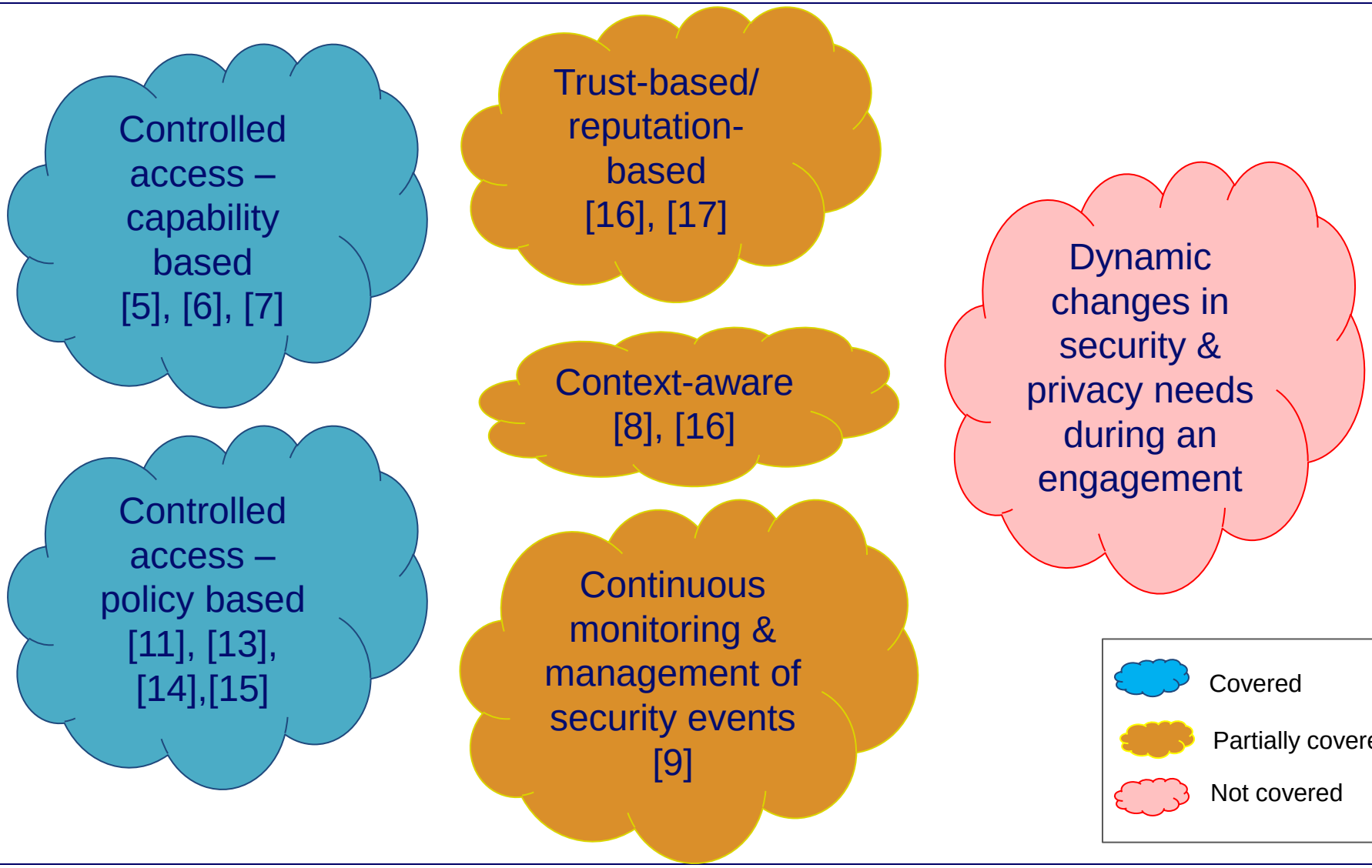
Usecase 1 - WBAN



Usecase 2 - Connected Car



Prior Art


Controlled access – capability based [5], [6], [7]
Trust-based/ reputation-based [16], [17]
Dynamic changes in security & privacy needs during an engagement
Context-aware [8], [16]
Controlled access – policy based [11], [13], [14],[15]
Continuous monitoring & management of security events [9]
Covered
Partially covered
Not covered

Prior Art

Author(s)	Highlights	Limitations
Skarmeta et al [5]	• Distributed capability-based access control mechanism based on digitally signed capability-token	Static and hence unsuitable for changing context and purpose, and for heterogeneous IoT networks with varying capabilities
Gusmeroli et al [6]	• Capability-based access control mechanism • Capability directly identifies the resource(s), the subject to which the rights have been granted, the granted rights, and the authorization chain.	• Requires issuing capabilities to all subjects • Not suitable for dynamically changing security and privacy requirements during progressive interactions.
Xin Huang et al [8]	• Context-aware k-anonymity policy • Anonymizes the identifiers of the data record/user so that it is not distinguishable from other users except when required.	• Privacy settings are not dynamically adapted during an interaction with another entity • Security-related aspects are not addressed.
GAMBAS [11]	• Policy-based privacy mechanism that enables secure exchange of information after authentication, key exchange, etc.	• Does not address the dynamic changes in privacy & security requirements during the course of an IoT interaction.

Prior Art

Author(s)	Highlights	Limitations
Pohls et al [9]	• Framework for security, privacy and trust for smart city IoT networks. • Includes continuous monitoring and management of security events, and automated adaptation of deployed security mechanisms to enable reconfigurations due to context change	• Requires explicit reporting of context change, and handles only a limited set of context parameters • Fails to adapt during the course of an interaction.
Neisse et al [16]	Context-aware and trust-based security & privacy framework Security policies are implemented as ECA rules.	• Does not dynamically adapt to changes in context, trust-level, environment, etc. during the interaction. • Limitations in scalability and deployability for new/unknown service-oriented and inter-IoT interaction scenarios
Gessner et al [17]	A security architecture for authorization, authentication, and privacy based on trust and reputation for IoT networks.	• Does not address dynamic adaptations of the privacy & security mechanism as the interaction progresses. • Peer-to-peer information collection and processing for trust and reputation computation may not scalable as the number of parties grow.

Need for this Paper

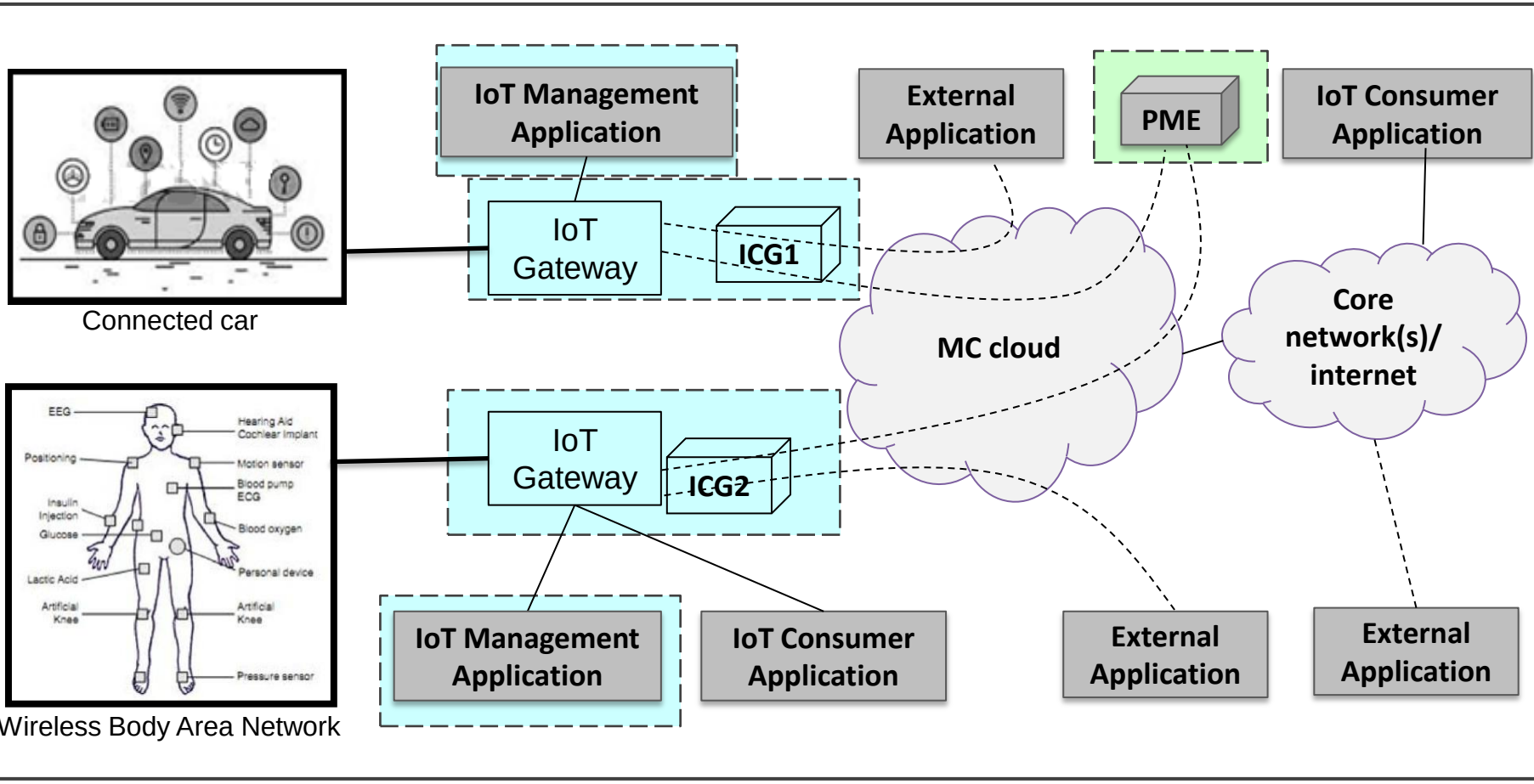
Need for a dynamic, adaptive privacy and security settings taking into consideration the context, purpose, collective past experiences and other factors

Definitions

- **Perception**: Is formed by an entity with regards to the set of possible interactions with a second entity, based on:
  - Own experience
  - Information from other sources and
  - Collective perception

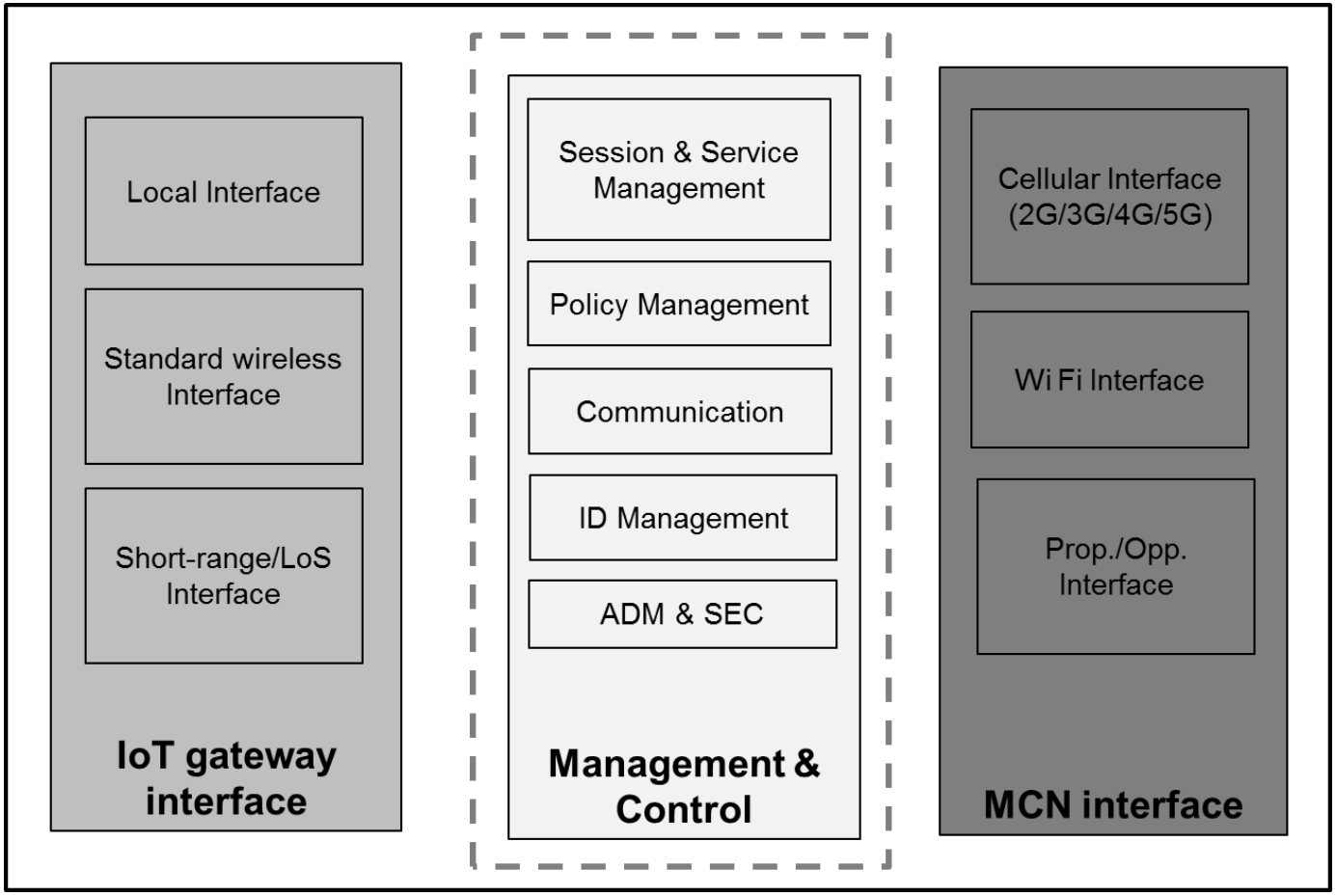
  Perception can evolve before, during and after an interaction.
- **Filter**: Is a mechanism that determines the extent of information to be allowed to pass through.
  - Set of rules and thresholds that will be applied on the messages / contents that are being passed through the filter.
  - Filter can be uni-directional or bi-directional.
- **Engagement**: Represents an interaction session for an IoT network with a second party involving a network (IoT or otherwise) that is interested to obtain or deliver one or more services, exchange information, etc.

Proposed Solution - Architecture



Reference: Ghosh, S. et al [18]

Proposed Solution – ICG Architecture



Reference: Ghosh, S. et al [18]

Proposed Solution - Architecture

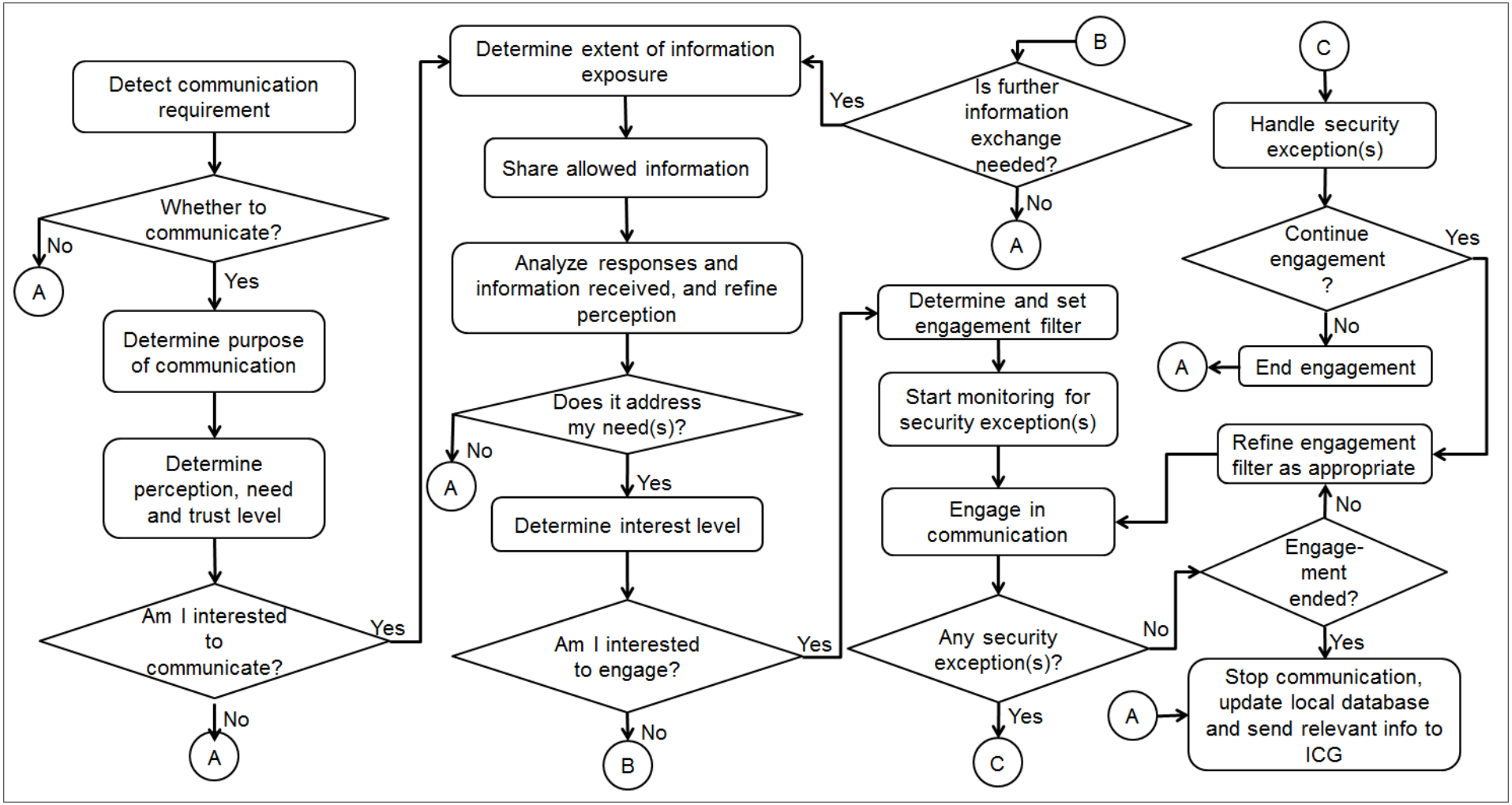
- IoT Gateway: Handles IoT network-specific aspects such as:
  - IoT-function, associated security & privacy at device and IoT-network level
  - Identity of component devices
  - Device and IoT network capability
  - Topology

  Also contains relevant information of neighboring IoT gateways and handles intra-IoT network communication aspects.
- Interconnect Gateway (ICG): Handles all aspects of inter-IoT communication including:
  - Managing the communication channels towards IoT Gateway and MC cloud
  - Session and service management
  - Security and privacy (broader view than IoTGW)
  - Identity management
  - Policy formulation and application
- MC Cloud: Macro-cellular network

Proposed Solution - Architecture

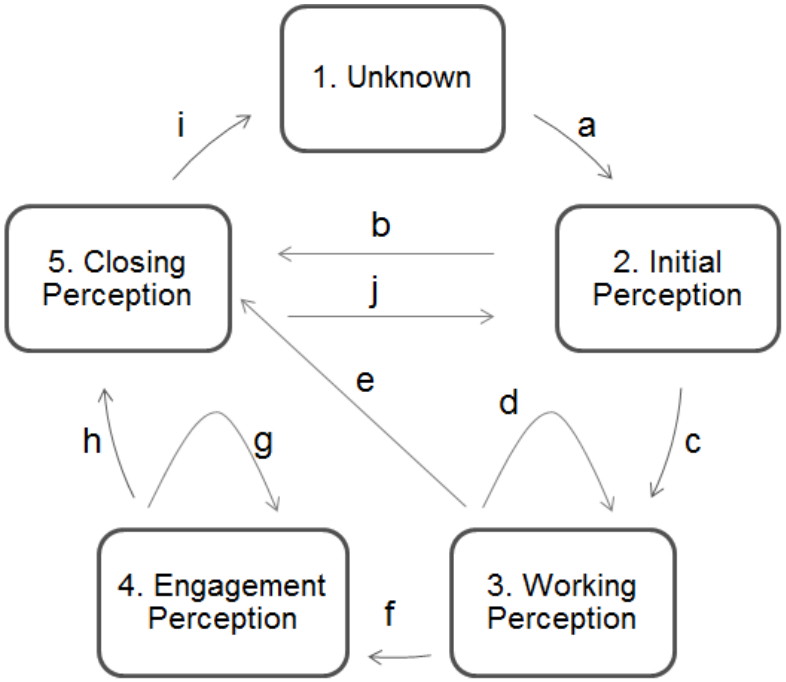
- Perception Management Entity (PME):
  - Collects perception-related inputs (PRI) from different sources
  - Organizes and manages PRI
  - Provides relevant inputs upon request from the ICG.
- IoT Management Application: Manages IoT network functions and policies.
- IoT Consumer Application: Makes use of information from one or more IoT devices and IoT networks to provide service(s) to the user, IoT network, or other entities.
- External Application: Any service-provider or third-party application that may interact with the IoT network.

Proposed Solution - Functioning



Perception Lifecycle

IoTGW Perception Lifecycle



ICG Perception Lifecycle

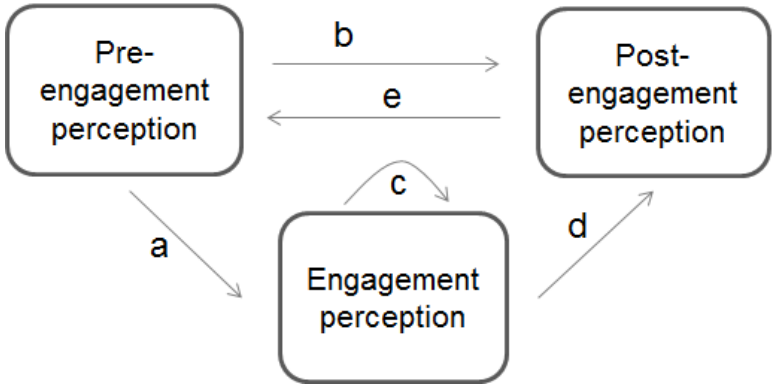
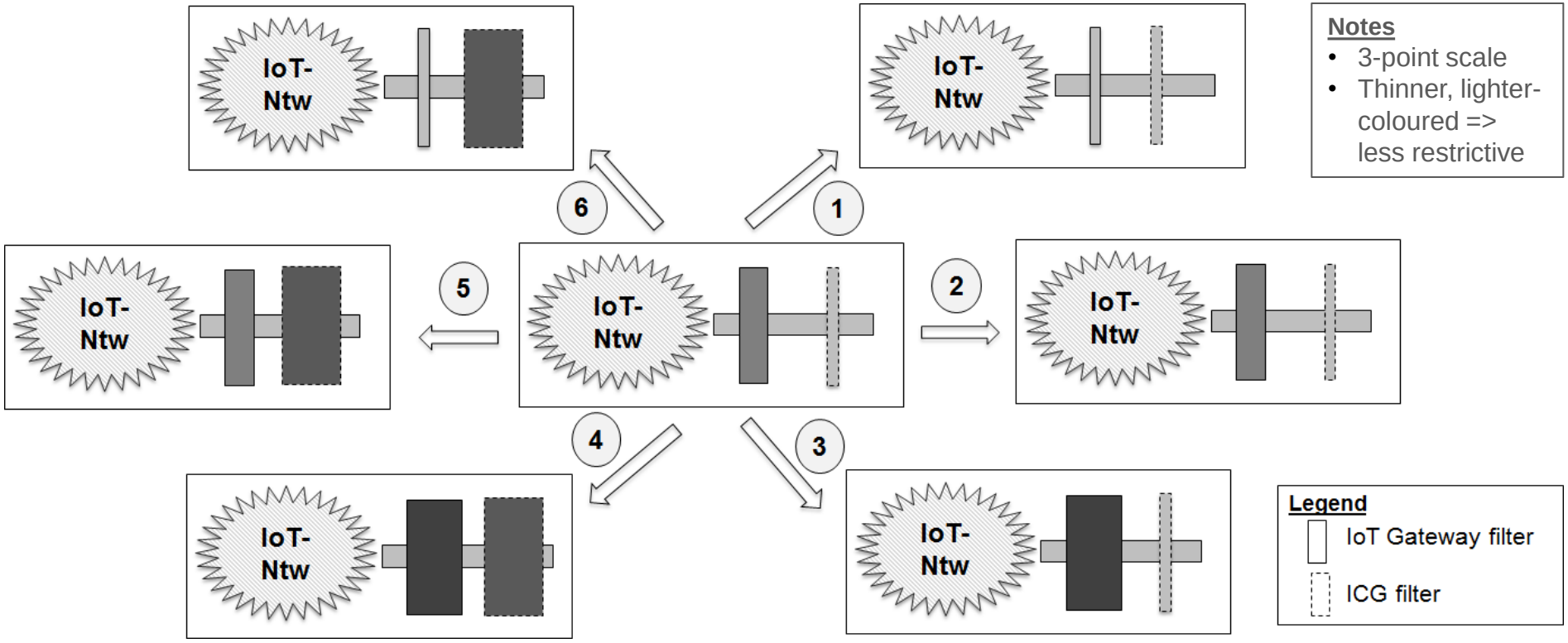


Illustration of Inter-IoT interaction



ICG Filter

- Formed based on perception input from PME, trust assumptions about IoT Gateway, etc.
- Concerned with network-level communication aspects
- Mostly static for a single engagement except for a few exceptions

IoT Gateway Filter

- Formed based on perception input from PME, trust assumptions about the ICG and based on own earlier perception.
- Highly dynamic, and changes continuously during the engagement.

Future Work

- Alignment of IoTGW and ICG perceptions, and correlation of the IoTGW and ICG filters
  - Will it lead to a more intelligent, accurate & optimized handling of security and privacy needs?
- Evaluate the benefits of stateful IoTGW and ICG filters across engagements
  - Taking into account the last filter setting for a similar engagement and the overheads involved.
- Examine security/privacy-related interactions between IoTGW and ICG for very short-lived engagements, and initial interactions with very low latency requirements
- Implement our approach in a real-world setting for connected cars and WBAN
  - Fine-tune the proposed mechanism to function better to enable wider deployability.

Conclusion

Recap

- IoT networks and their interactions to realize services those are new and even unimagined today is likely to proliferate in the years to come.
- Security and privacy requirements will change depending on the context, purpose, etc., and will change dynamically during an engagement.

We have proposed a context-aware, purpose-aware, dynamic, adaptive and composite privacy and security mechanism. The proposed mechanism is highly adaptive and scalable, and hence can fulfill the security and privacy requirements of almost any kind of real-world IoT network.

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Thank you!

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