

SCIENCES

Networks and Communications, Field Director – Guy Pujolle

Network Management and Control, Subject Head – Francine Krief

Intelligent Security Management and Control in the IoT

Coordinated by

Mohamed-Aymen Chalouf

Color Section

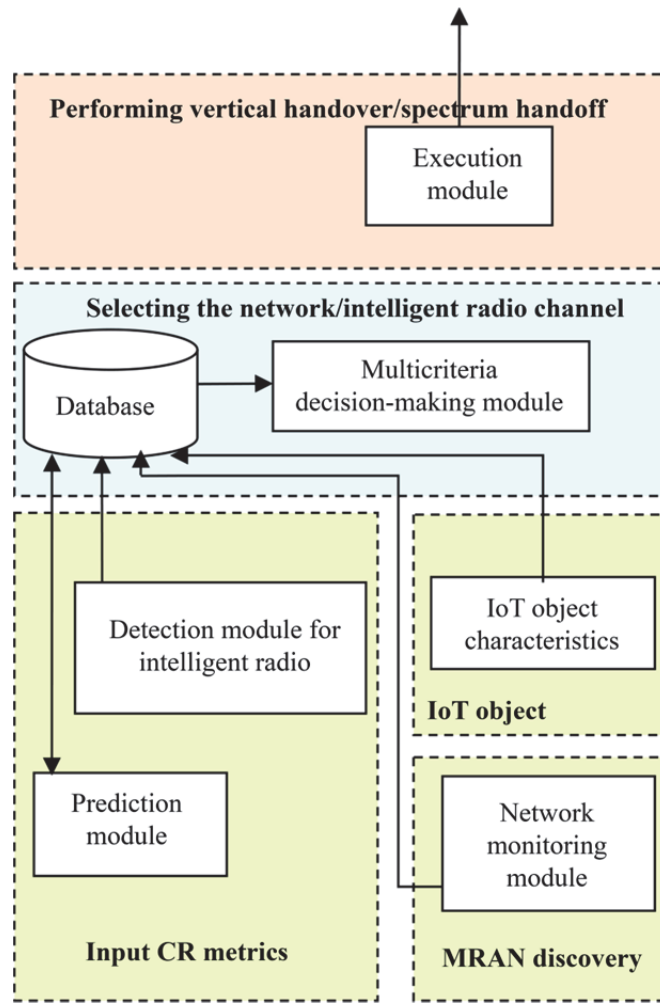


Figure 1.1. Proposed architecture for a context aware IoT device/object

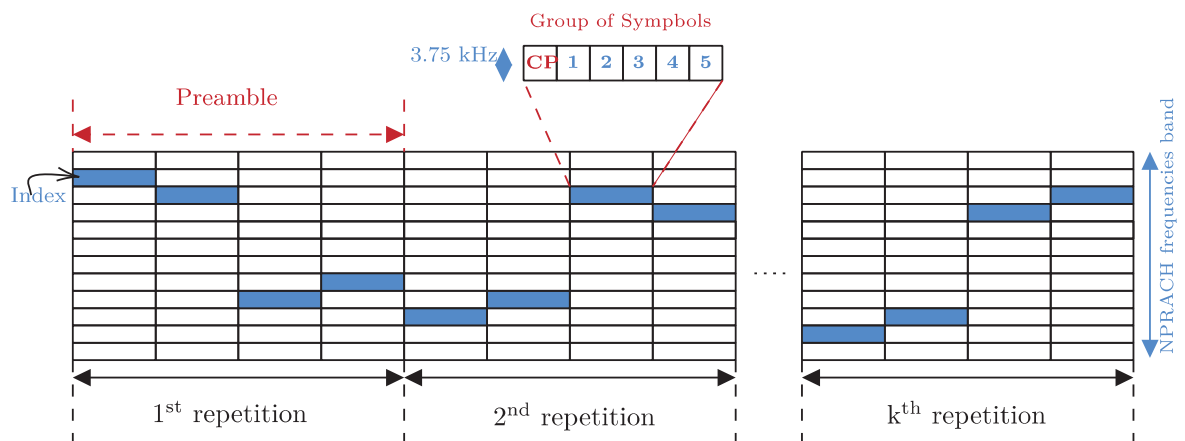


Figure 2.3. Structure of a preamble sequence

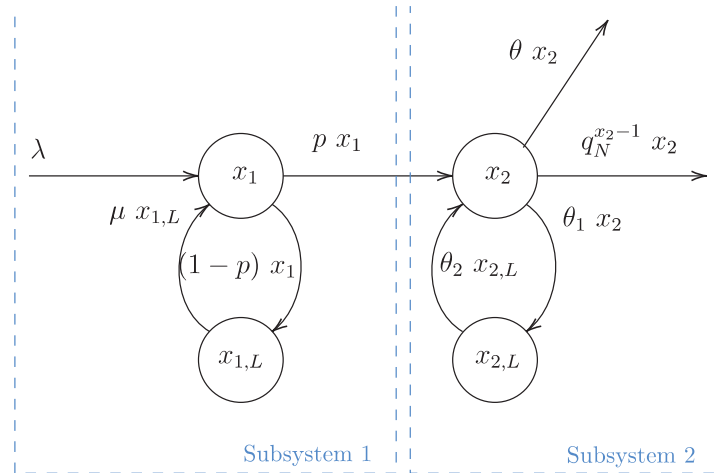


Figure 2.5. System model

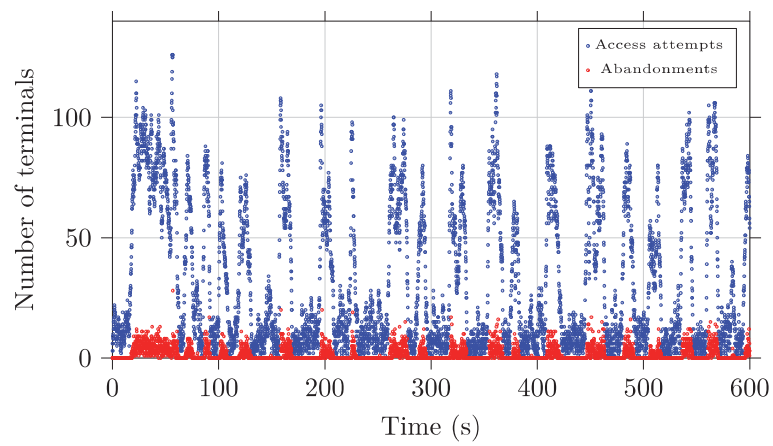


Figure 2.13. Access attempts (blue) and abandonments (red) with the adaptive controller

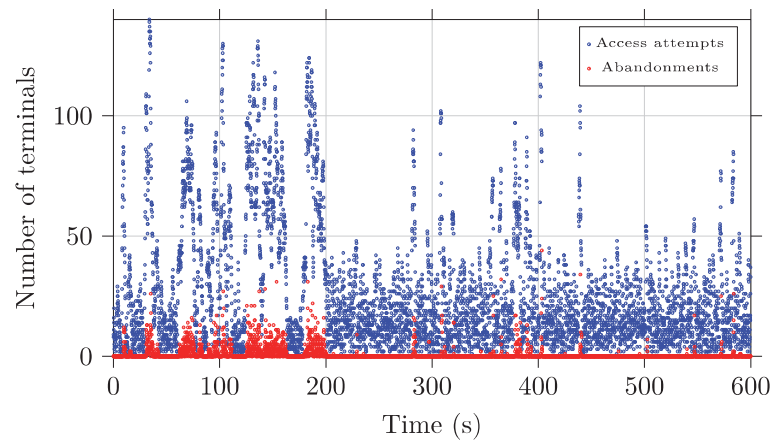


Figure 2.14. Access attempts (blue) and abandonments (red) with the controller using TD3

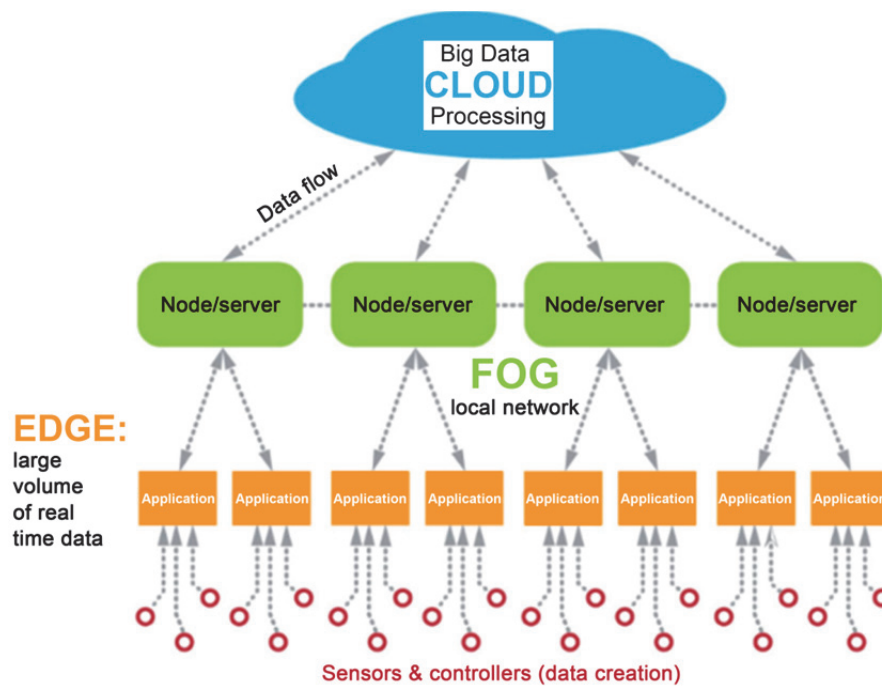


Figure 3.2. Cloud, Fog and Edge

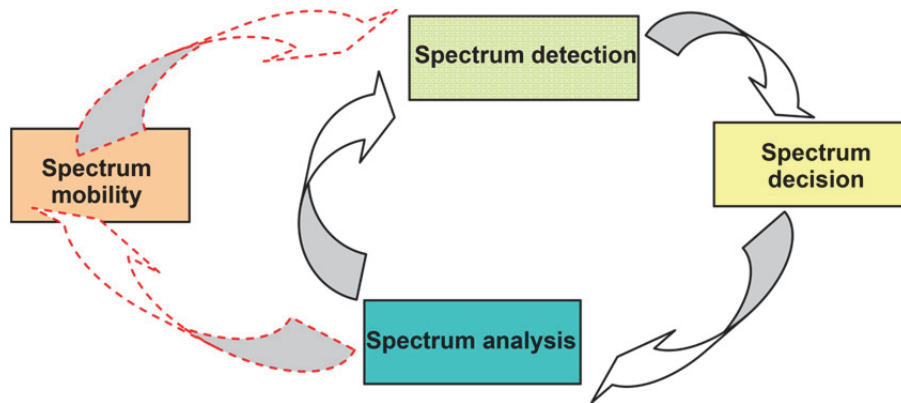


Figure 3.3. Features for spectrum management in intelligent radio

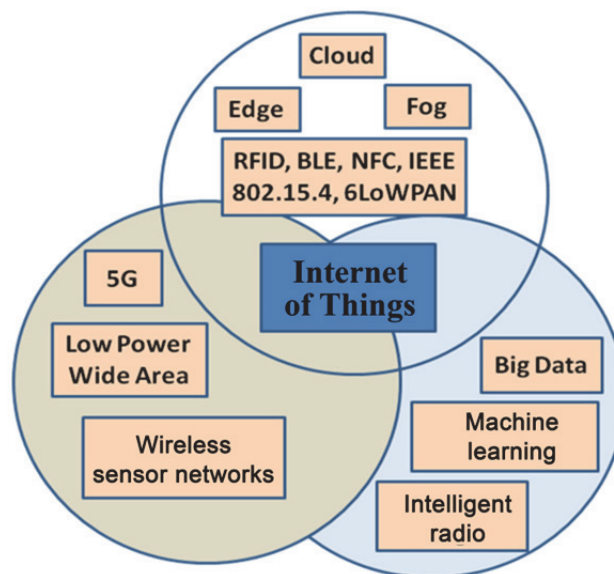


Figure 3.4. Integration of multiple technologies in the IoT

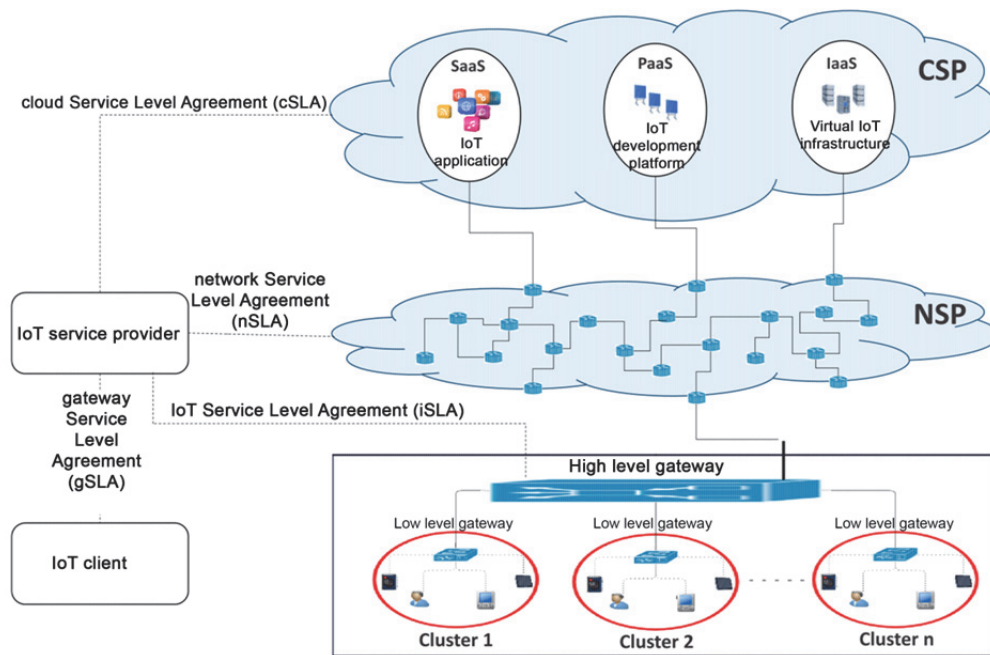


Figure 4.1. Architecture of the Internet of Things (Khalil et al. 2018)

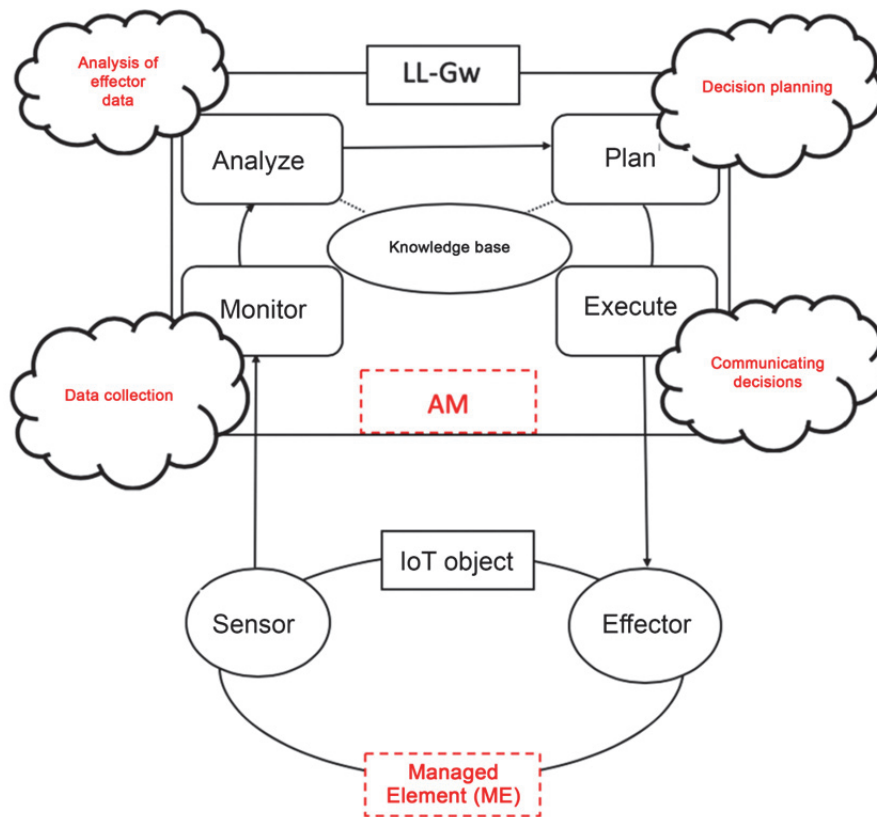


Figure 4.3. MAPE-K loop from the IoT energy self-optimization framework

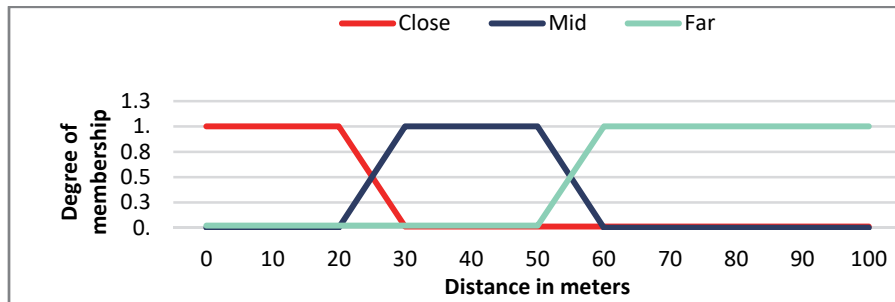


Figure 4.4. Membership functions of the "distance" parameter

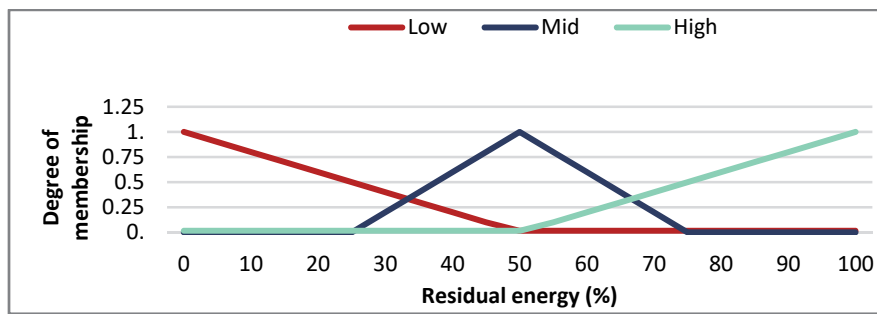


Figure 4.5. Membership functions of the "residual energy" parameter

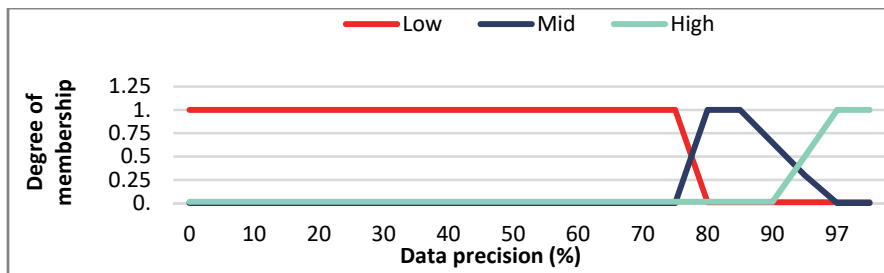


Figure 4.6. Membership functions of the "precision" parameter

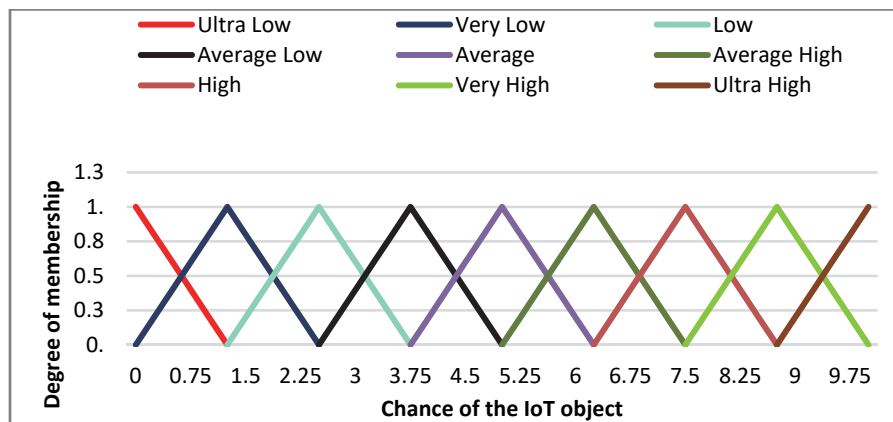


Figure 4.7. Membership functions of the output parameter

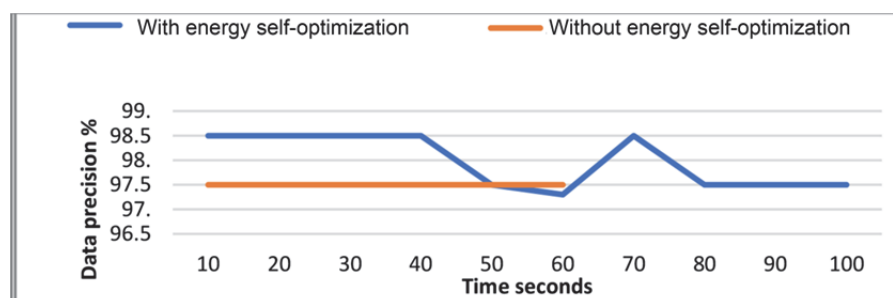


Figure 4.11. Average precision of the information recorded in scenario 4

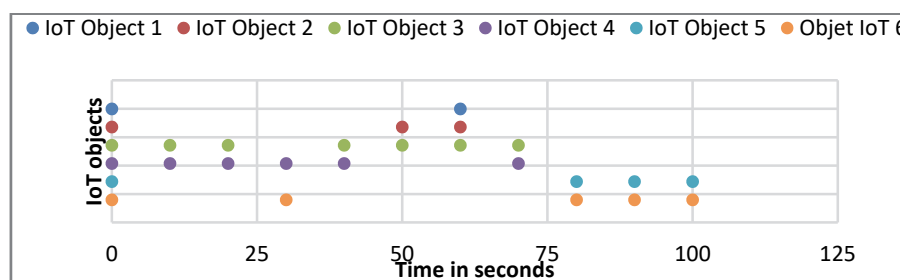


Figure 4.12. Selection of IoT objects over time in scenario 4

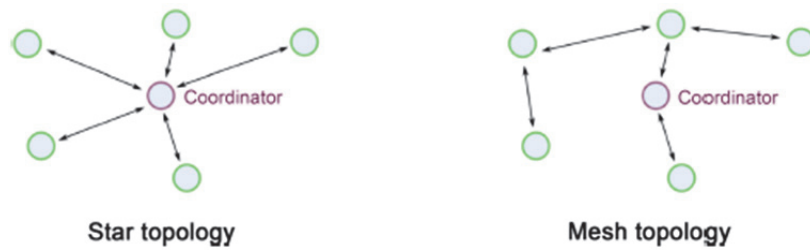


Figure 5.1. Example of star topology and mesh topology in an IoT network

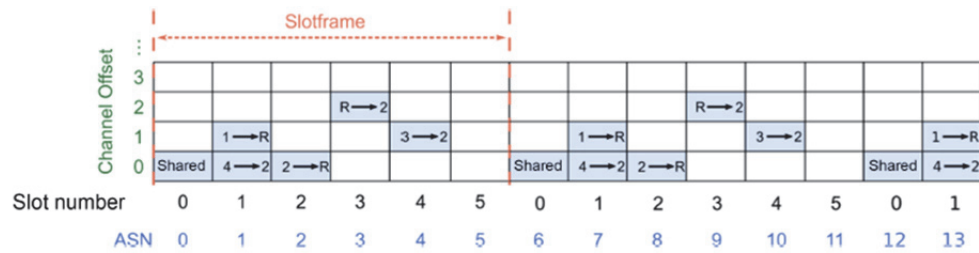


Figure 5.2. Example of a size 6 slotframe, for a 4-node network and a coordinator using TSCH

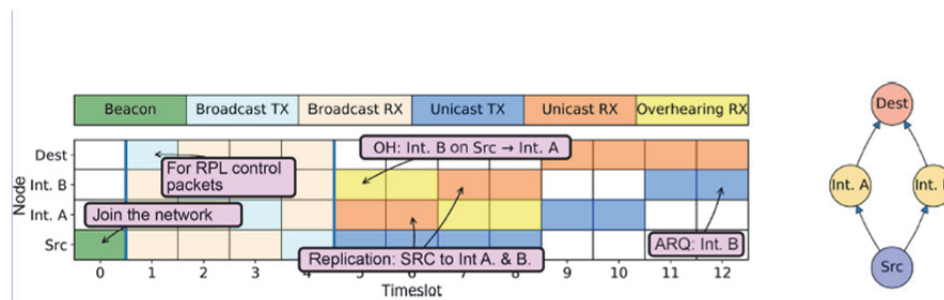


Figure 5.3. Example of TSCH schedule and topology showing Replication, Overhearing and ARQ operations

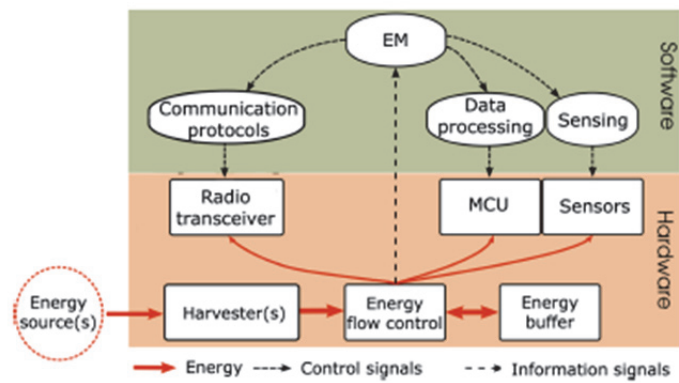


Figure 6.1. Architecture of an energy-harvesting sensor node

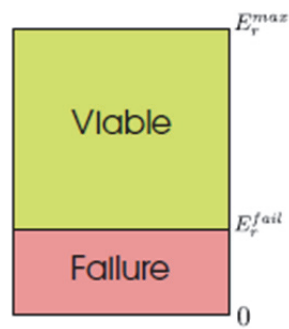


Figure 6.2. Energy buffer thresholds

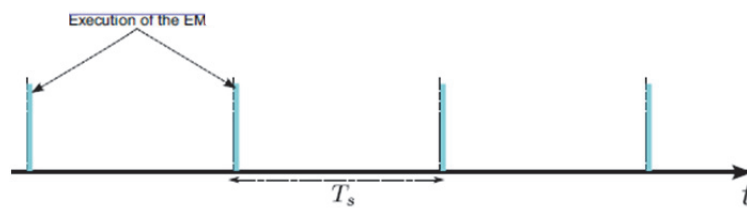


Figure 6.3. Periodic execution of the EM

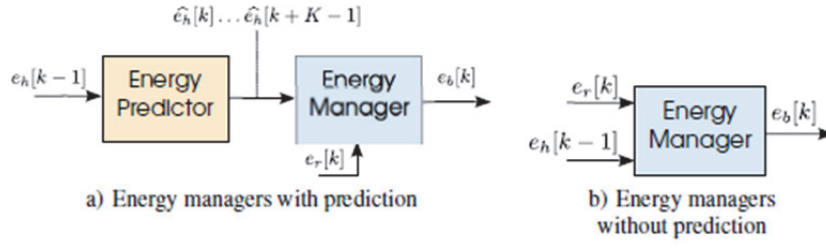


Figure 6.4. Architecture of energy managers with and without prediction

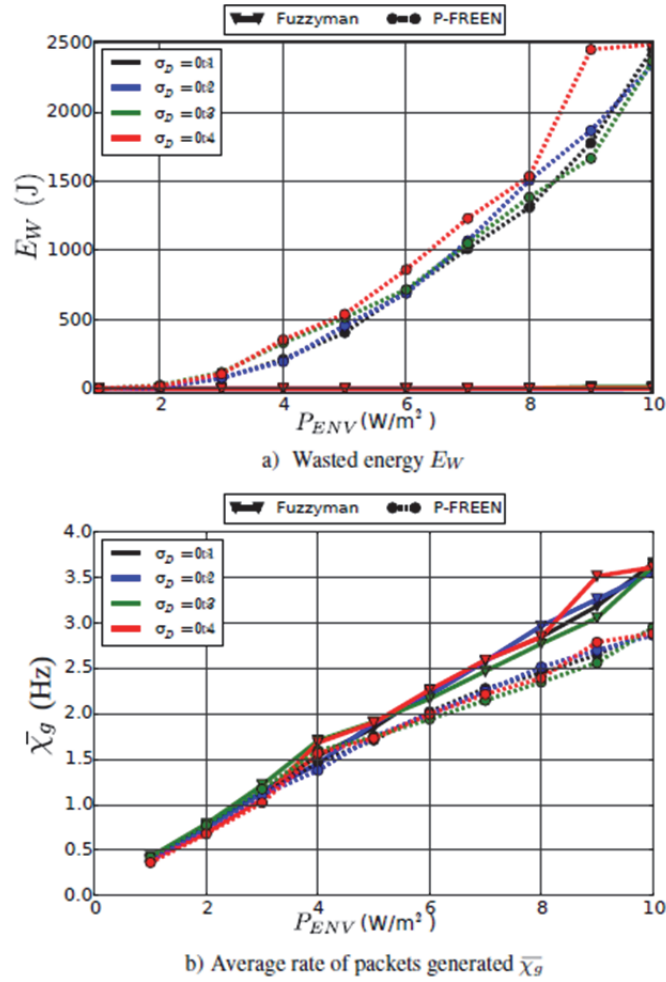


Figure 6.7. Performance of Fuzzyman and P-FREEN depending on P_{ENV} for different values of σ_D .

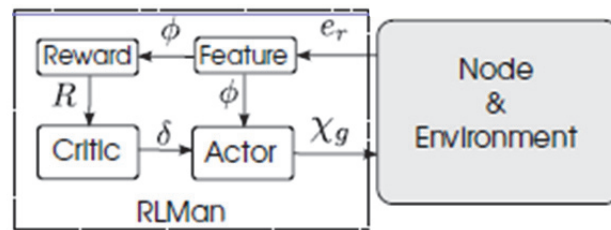
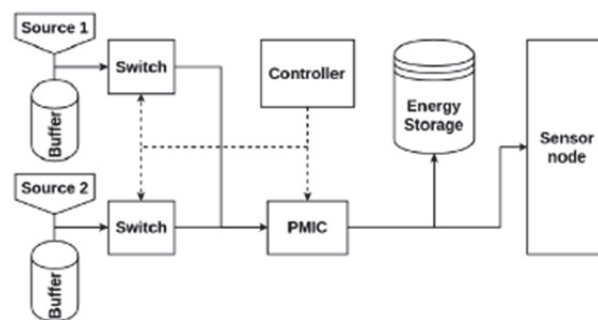


Figure 6.8. Global RLMan architecture



a) Architecture of energy source commutation



b) Prototype linking LoRa and multisource harvesting

Figure 6.10. Architecture of harvesting multisource energy for LoRa standard

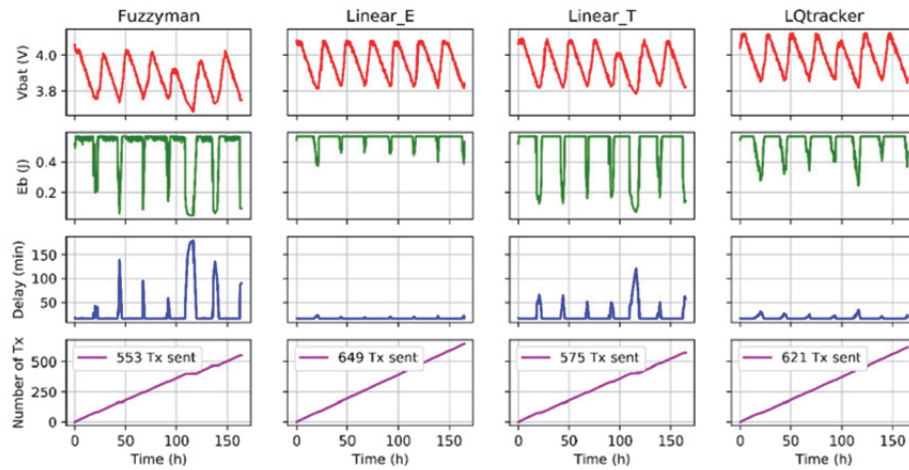


Figure 6.11. Performance of different EMs over 7 days of execution

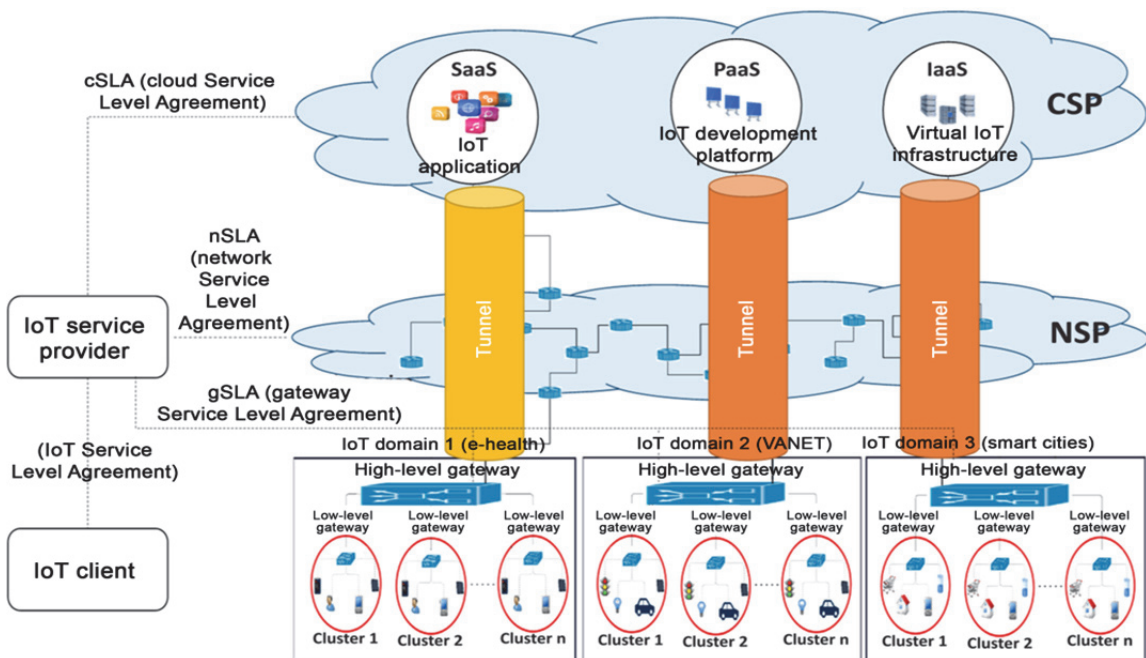


Figure 7.3. Security architecture for the Internet of Things

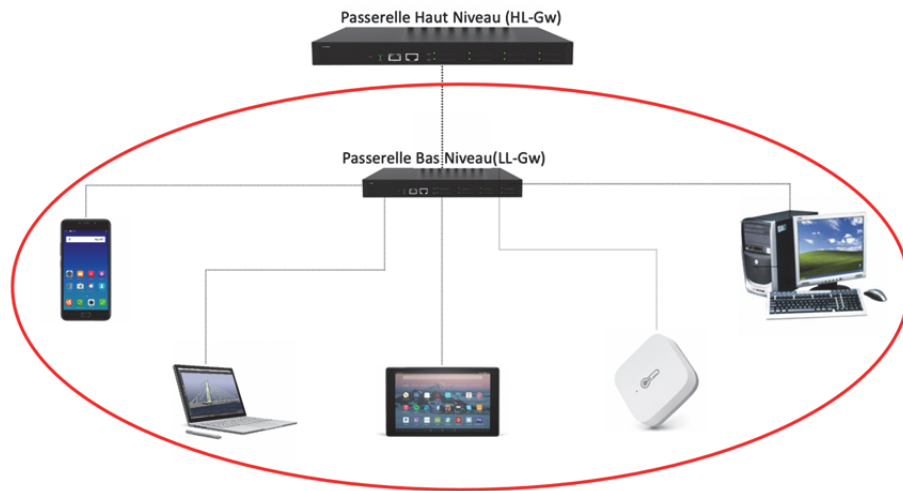


Figure 7.4. IoT access control environment

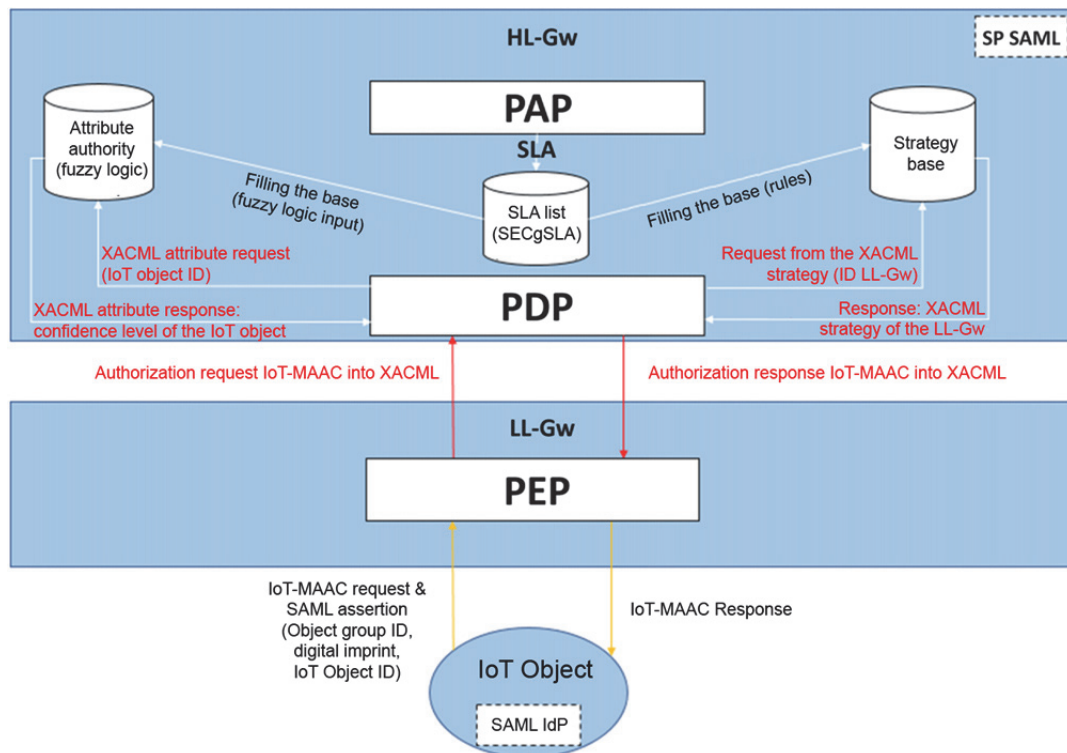


Figure 7.5. IoT-MAAC-MAAC access control architecture

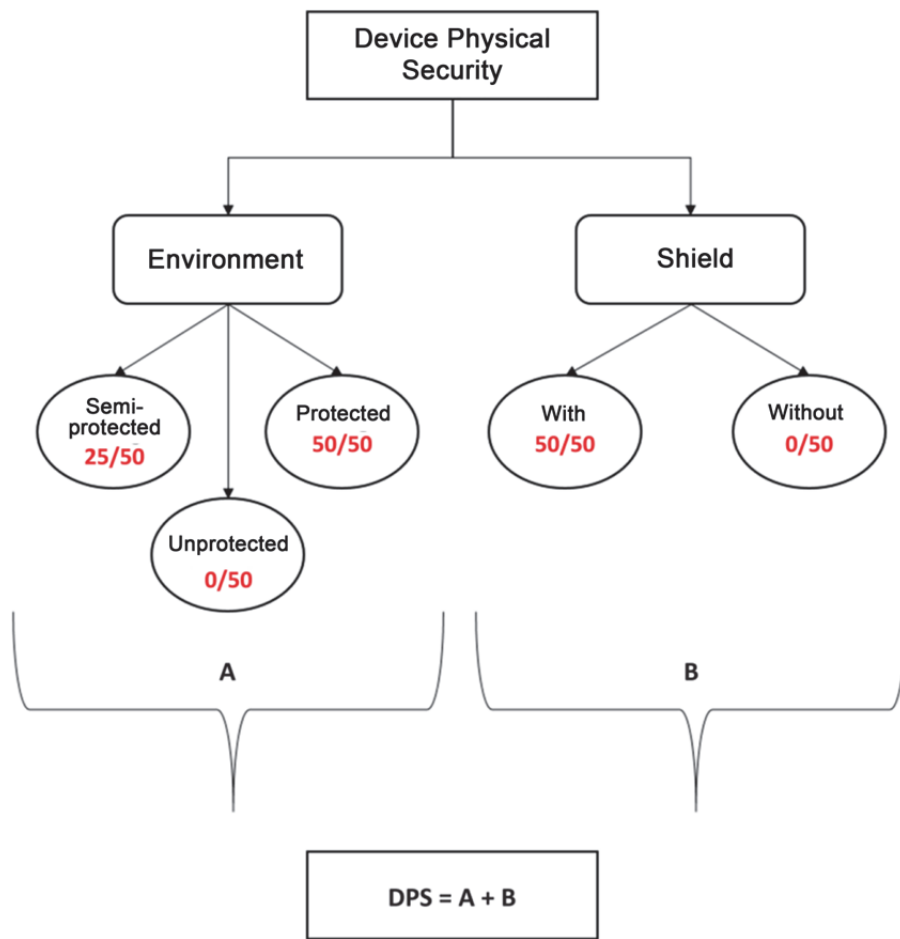


Figure 7.6. DPS notation system

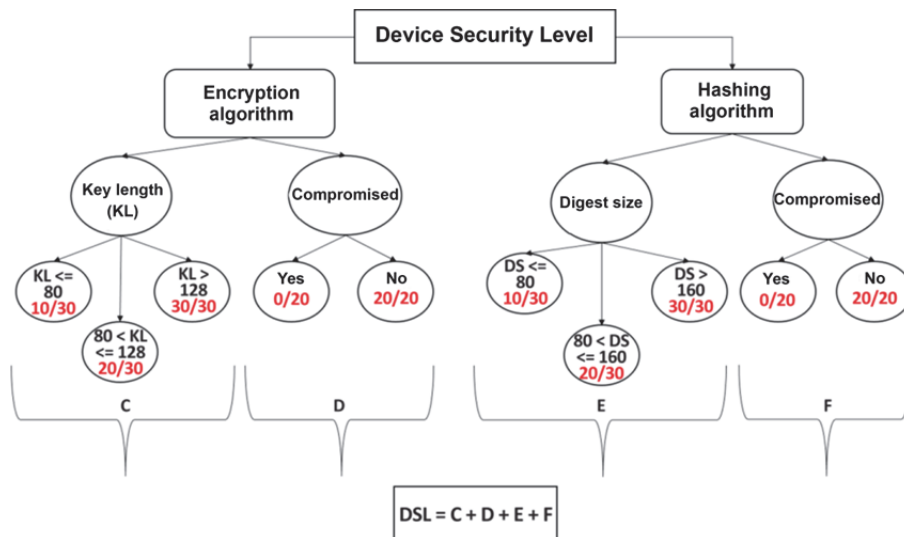


Figure 7.7. DSL notation system

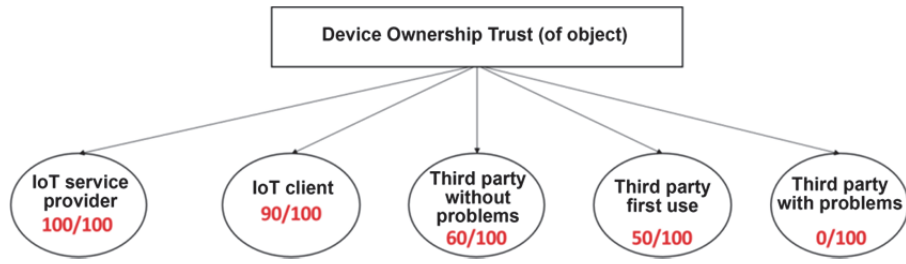


Figure 7.8. DOT notation system

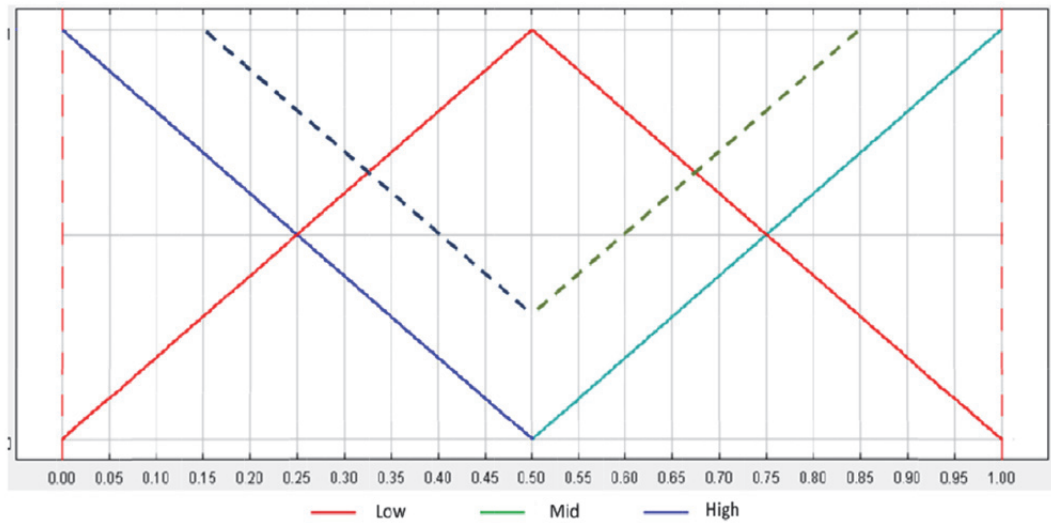


Figure 7.9. DPS, DSL and DOT membership functions

Decision Making Algorithm [LL-Gw_ID]

```

Strategy ← Retrieve_Strategy_from_Strategy_Directory (LL-Gw_ID)
Number_Policies ← Retrieve_Number_Policies (Strategy);
for i ∈ (1, Number_Policies) do
  if ( Group_Object_ID (IoT Object) = Group_Object_ID (Policy(i)) ) then
    Number_Rules ← 2;
    for i ∈ (1, Number_Rules) do
      if ( Attributes (Rule (i) = 1) ) then
        return Deny;
      else
        if [( IoT Object ID) ∈ (List_Object [Group Object ID]) )
          & ( Fingerprint (IoT Object) = Fingerprint (Rule(i)) )
          & ( Trust_Level (IoT Object) >= Trust_Level (Rule(i)) )
          & ( Request_Access_Time (Start) >= Start_Time(Rule(i)))
          & ( Request_Access_Time(End) < End_Time(Rule(i))) ] then
          return Permit;
        end if
      end if
    end for
  end if
end for
return NotApplicable
  
```

Figure 7.10. IoT-MAAC decision-making algorithm


```

<saml:Assertion xmlns:saml="urn:oasis:names:tc:SAML:2.0:assertion"
  Version="2.0"
  IssueInstant="2019-02-12T15:26:12Z">
  <saml:Issuer Format="urn:oasis:names:SAML:2.0:nameid-format:entity">
    IoT Object 1
  </saml:Issuer>
  <saml:Subject>
    <saml:NameIdentifier>IoT Object 1</saml:NameIdentifier>
  </saml:Subject>
  <saml:Conditions NotBefore="2019-02-12T15:26:12Z" NotOnOrAfter="2019-02-12T15:28:12Z"/>
  <saml:AttributeStatement>
    <saml:Attribute Name="Fingerprint">
      <saml:AttributeValue>$oàikj^plnrusdn=çkdjd21587uyrzertzvssrh</saml:AttributeValue>
    </saml:Attribute>
    <saml:Attribute Name="IoT_Object_ID">
      <saml:AttributeValue>00:50:56:C0:00:01</saml:AttributeValue>
    </saml:Attribute>
    <saml:Attribute Name="Group_Object_ID">
      <saml:AttributeValue>1</saml:AttributeValue>
    </saml:Attribute>
  </saml:AttributeStatement>
</saml:Assertion>

```

Figure 7.11. SAML assertion of the IoT object

```

<Request xmlns="urn:oasis:names:tc:xacml:2.0:context:schema:os" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <Subject>
    <Attribute AttributeId="urn:oasis:names:tc:xacml:1.0:subject:subject-id" DataType="http://www.w3.org/2001/XMLSchema#string">
      <AttributeValue>IoT Object 1</AttributeValue>
    </Attribute>
    <Attribute AttributeId="Fingerprint" DataType="http://www.w3.org/2001/XMLSchema#string">
      <AttributeValue>$oàikj^plnrusdn=çkdjd21587</AttributeValue>
    </Attribute>
    <Attribute AttributeId="IoT_Object_ID" DataType="http://www.w3.org/2001/XMLSchema#string">
      <AttributeValue>11:12:13:14:15:16</AttributeValue>
    </Attribute>
    <Attribute AttributeId="Group_Object_ID" DataType="http://www.w3.org/2001/XMLSchema#string">
      <AttributeValue>1</AttributeValue>
    </Attribute>
  </Subject>
  <Resource>
    <Attribute AttributeId="urn:oasis:names:tc:xacml:1.0:resource:resource-id" DataType="http://www.w3.org/2001/XMLSchema#string">
      <AttributeValue>11:15:16:18:17:16</AttributeValue>
    </Attribute>
  </Resource>
  <Action>
    <Attribute AttributeId="urn:oasis:names:tc:xacml:1.0:action:action-id" DataType="http://www.w3.org/2001/XMLSchema#string">
      <AttributeValue>read</AttributeValue>
    </Attribute>
    <Attribute AttributeId="urn:oasis:names:tc:xacml:1.0:action:action-id" DataType="http://www.w3.org/2001/XMLSchema#string">
      <AttributeValue>write</AttributeValue>
    </Attribute>
  </Action>
  <Environment>
    <Attribute AttributeId="NotBefore" DataType="http://www.w3.org/2001/XMLSchema#datetime">
      <AttributeValue>2019-02-12T15:26:12Z</AttributeValue>
    </Attribute>
    <Attribute AttributeId="NotAfter" DataType="http://www.w3.org/2001/XMLSchema#datetime">
      <AttributeValue>2019-02-12T15:26:12Z</AttributeValue>
    </Attribute>
  </Environment>
</Request>

```

Figure 7.12. XACML authorization request from the LL-Gw in IoT-MAAC

```

<Response xmlns="urn:oasis:names:tc:xacml:2.0:context:schema:os" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <Result>
    <Decision>Permit</Decision>
    <Status>
      <StatusCode Value="urn:oasis:names:tc:xacml:1.0:status:ok"/>
    </Status>
  </Result>
</Response>

```

Figure 7.13. XACML response from the HL-Gw in IoT-MAAC

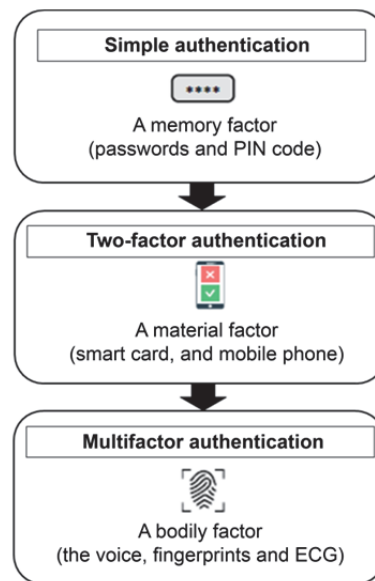


Figure 8.2. The evolution of authentication methods from simple authentication to strong authentication (Ometov and Bezzateev 2017)

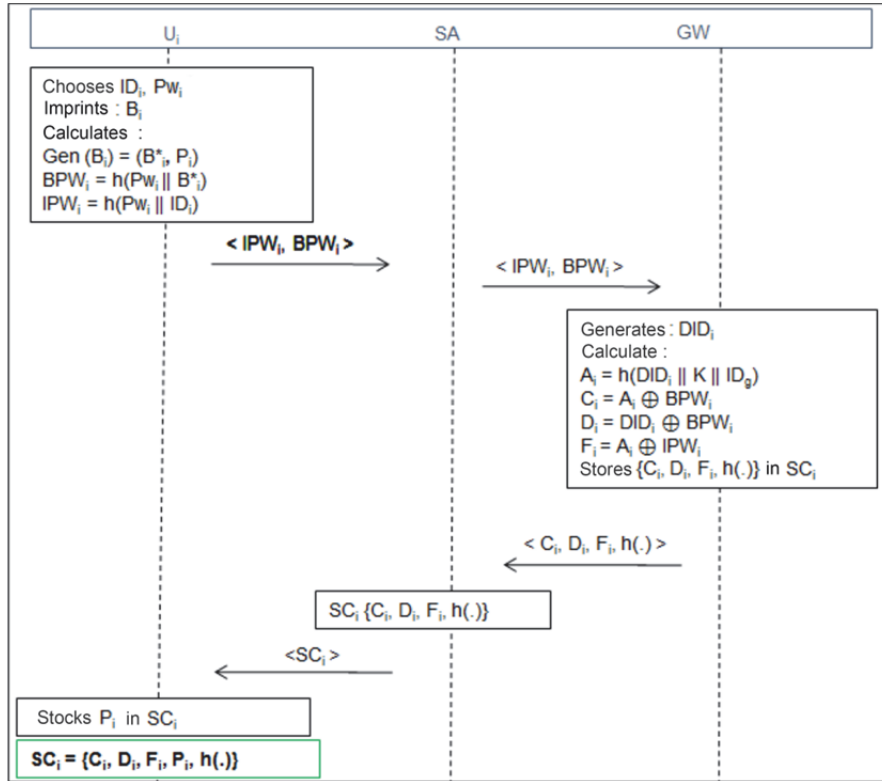


Figure 8.3. Registration phase of Sammoud et al. (2020c)

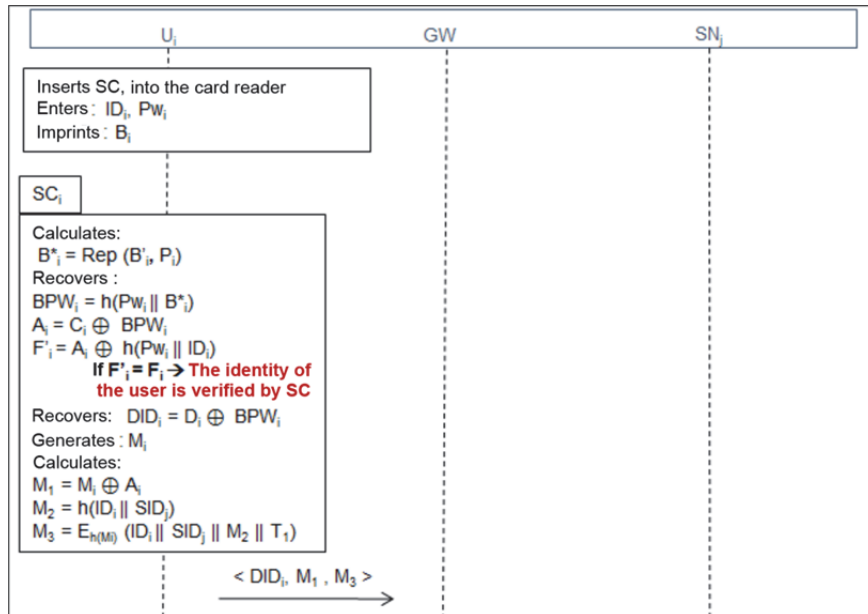
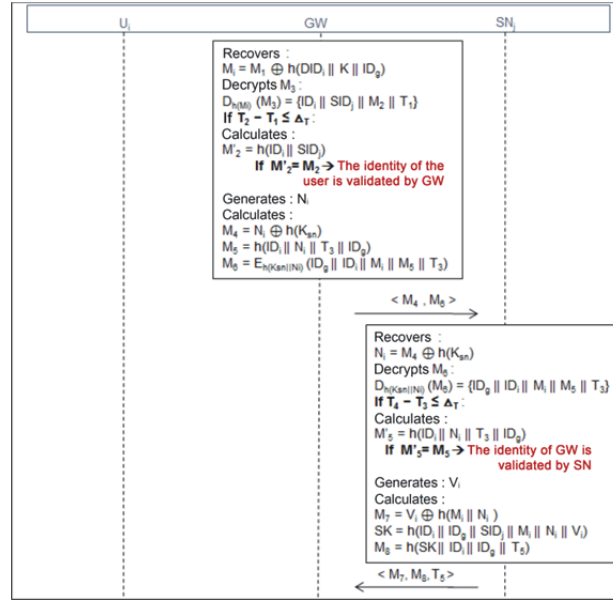
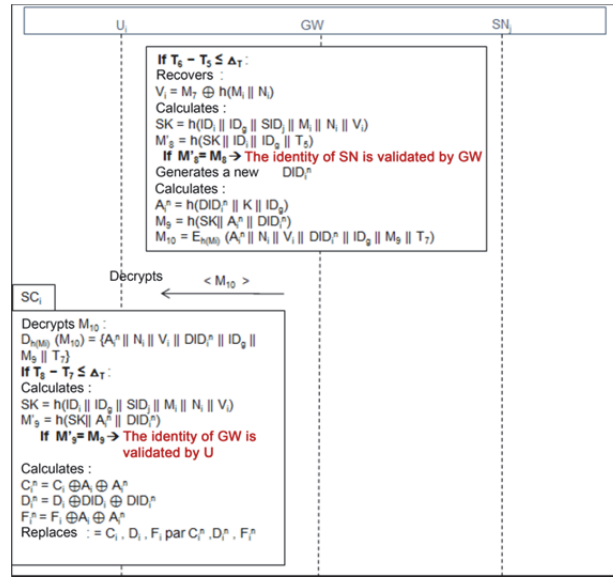


Figure 8.4. Login phase of Sammoud et al. (2020c)



a)



b)

Figure 8.5. a) Authentication phase of Sammoud et al. (2020c);
b) Protocol authentication stage of Sammoud et al. (2020c) (the continuation)

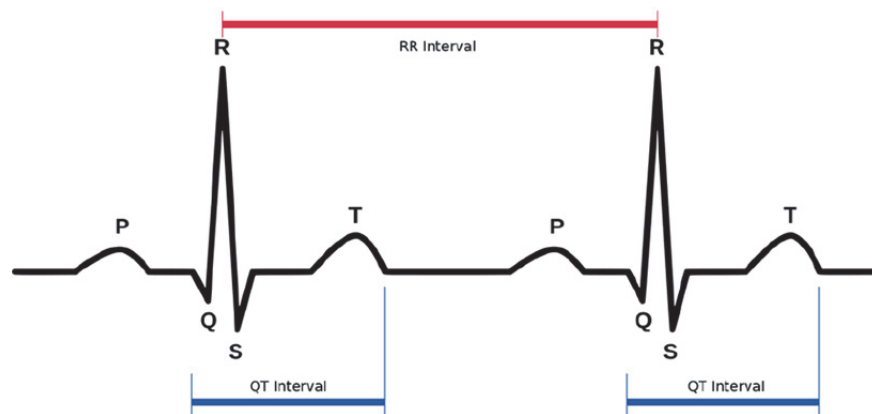


Figure 8.6. An ECG sequence (Sammoud et al. 2020a)

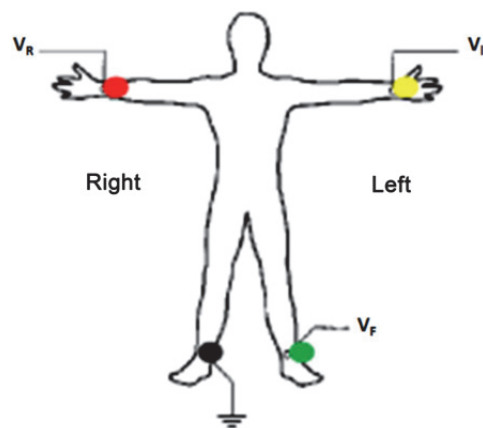


Figure 8.8. Acquiring an ECG signal

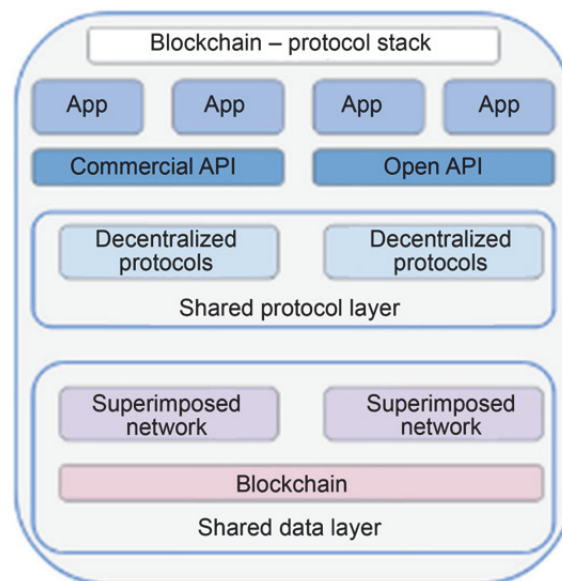


Figure 9.1. Blockchain architecture (Che et al. 2019)

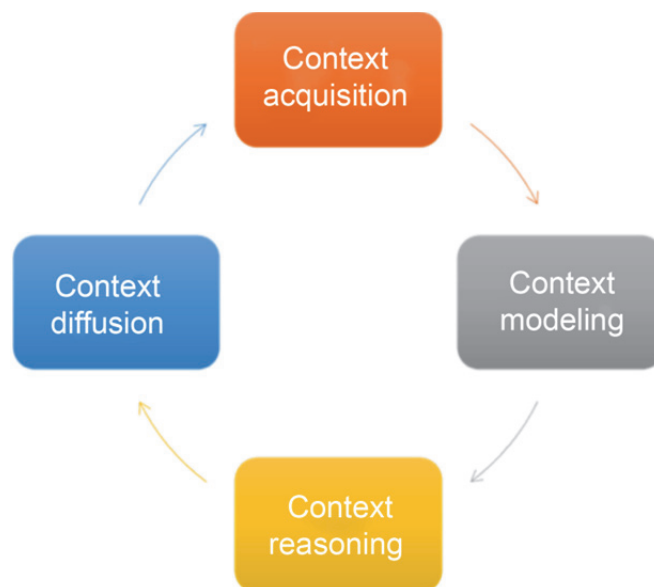


Figure 10.1. Lifecycle of a context

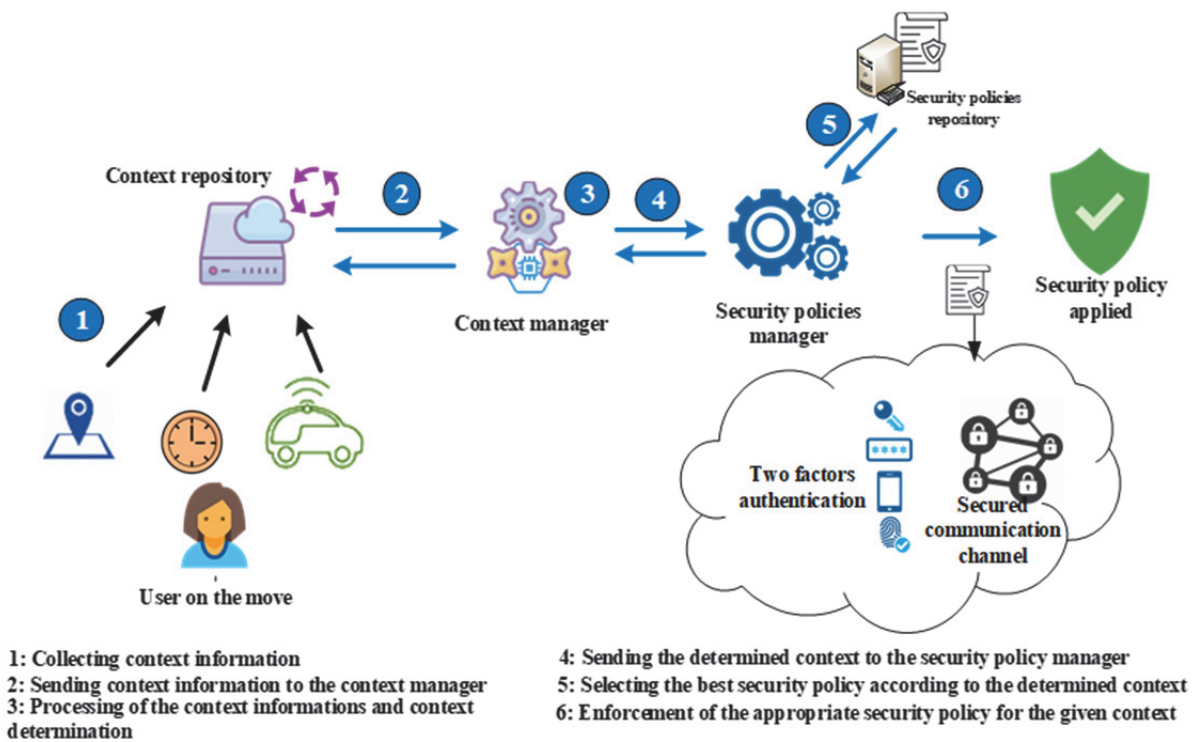


Figure 10.2. Example of implementing context-aware security (Sylla et al. 2021)

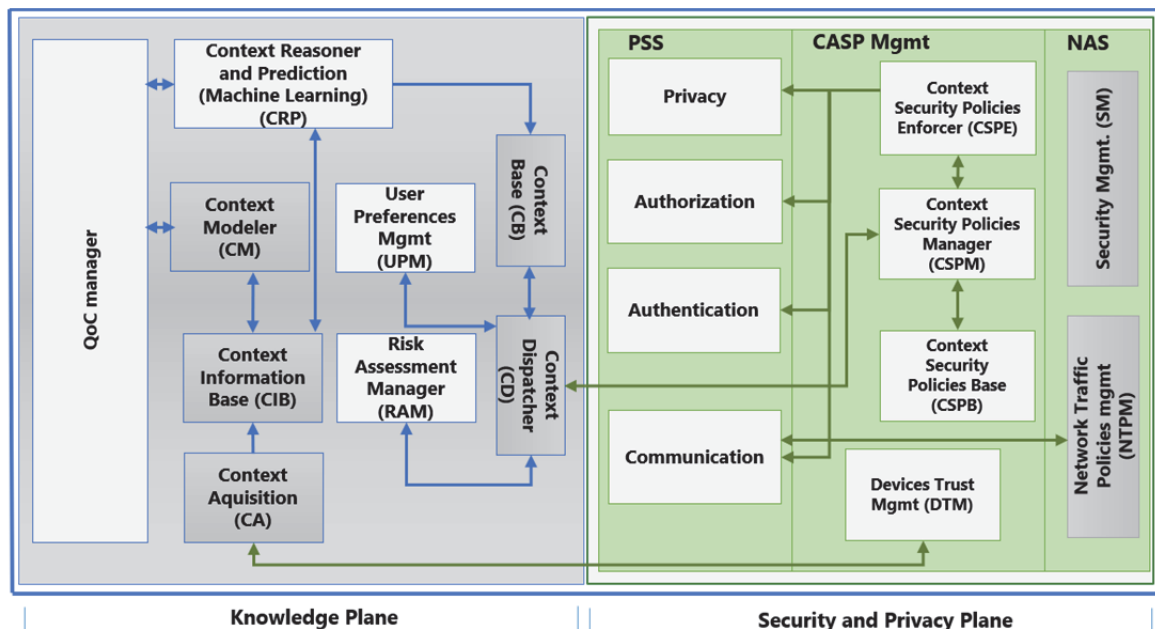


Figure 10.3. CASPaaS architecture (Sylla et al. 2020)

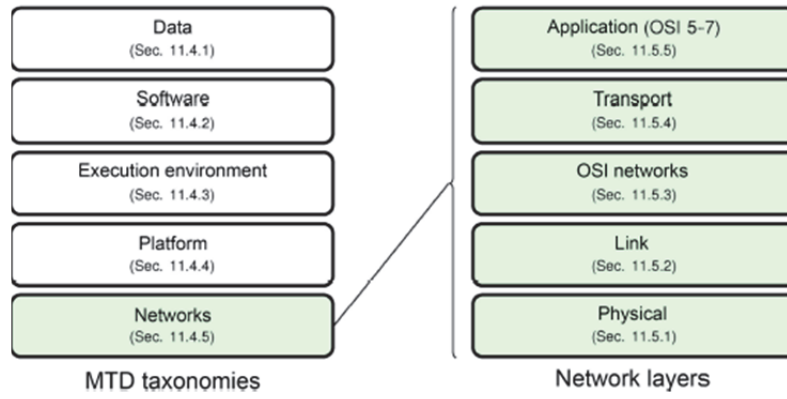


Figure 11.2. MTD taxonomies and network layers (with a reference to the section in which we study them)

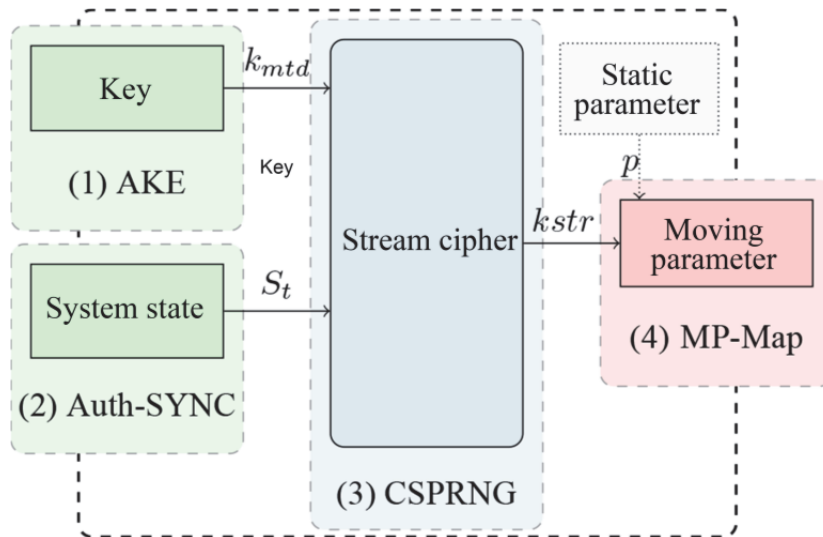


Figure 11.3. Components of the proposed MTD framework