

WHITE PAPER

Standardized Machine-to-Machine (M2M) Software Development Platform

Standardized service layer and APIs create a common framework and roadmap for cellular operators, service providers and device manufacturers

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1 Executive Summary

Thanks to advances in wireless communications, embedded systems, and IP networking, Machine-to-Machine (M2M) communications provide a huge opportunity for growth in M2M Service Applications. Future M2M Solutions are envisioned to connect billions of existing and new devices, ranging from high-end smart mobile terminals to low-cost resource-constrained wireless sensors or Radio Frequency Identification (RFID) tags. M2M technologies can be beneficially applied to a broad range of use cases for smart grid, telematics, eHealth/mHealth, vehicular networking and systems, industry control, home automation, and environmental monitoring.

Current M2M markets, however, are highly fragmented. Various vertical M2M solutions have been designed independently and separately for different applications, which inevitably impacts or even impedes large-scale M2M deployment. Today's deployments also pose additional technical challenges in managing large amounts of disparate M2M devices, security guarantee, and service discovery.

The M2M standards (i.e. ETSI TC M2M, oneM2M, etc.) can accelerate the development and reuse of service layer solutions. This white paper illustrates how InterDigital's suite of M2M solutions allow Solution Providers to capture the full potential of their M2M businesses.

InterDigital's Standardized Machine-to-Machine Software Development Platform (M2MSDP) provides a standard M2M middleware solution with common Application Programming Interfaces (APIs) for scalable and horizontal M2M services, featuring:

- **Standardized End-to-End (E2E) Solution:** Integrates all M2M entities from M2M Applications, M2M Devices, M2M Gateways, to M2M Servers as an E2E and fully Standards-compatible solution. A Converged M2M Gateway facilitates advanced local proxy and bulk management services for devices behind a Gateway;
- **Scalable Service Platform:** Supports Gateway-to-Gateway, Device-to-Device peer communications and interactions to significantly improve scalability, reliability and security. Additionally, standards-based dla/mlD/mla/mlm reference points are also supported;
- **Service-Oriented Architecture:** Supports peer Service Capabilities (SCs) for M2M Devices, M2M Gateways, and M2M Servers that enable service providers to generate new revenues from M2M via service platforms. Advanced features include platform-agnostic and smooth binding with HyperText Transfer Protocol (HTTP) and Constrained Application Protocol (CoAP);
- **RESTful Architecture:** Supports a Client/Server-based RESTful architecture and a hierarchical resource tree, simplifying and optimizing resource manipulations for a broad range of M2M Devices, especially constrained M2M Devices. Enables quick and efficient M2M application development;

- **Efficient Interworking with Cellular MTC:** Supports seamless integration of InterDigital's M2M Service Capability Layer (SCL) and Cellular Machine Type Communications (MTC) functionalities, and accordingly efficient interactions between M2M SCL and MTC functionalities;
- **Configurable Charging:** Allows for policy-based configurable trigger functions as well as record storing ability to correlate charging records from multiple entities (i.e. cellular and service platforms such as M2M or D2D services); support both offline and online charging;
- **InterNetworking via Interworking Proxy Unit (IPU):** Used to connect and convert existing or legacy service platforms into a standard-based platform without a complete overhaul. It is available in source or binary packages;
- **Lightweight Device Management:** Supports a RESTful and lightweight device management approach via M2M Gateways that cater to M2M requirements, especially from constrained M2M Devices;
- **Cognitive Semantic Services:** Supports cognitive, non-opaque data management including intelligent data process, mining and analytics to enable semantic data services at M2M service application layer;
- **Automated Service Discovery:** Significantly reduces management costs and automates the deployment process by removing human involvement and offline provisioning;
- **Autonomous Integrity Validation:** supports policy-based M2M Devices and M2M Gateways integrity validation to improve reliability and dependability;
- **M2M Cloud Server Development Platform:** cloud-based M2M platform supports virtualized and configurable M2M Server, which can be in the private cloud or public cloud. Better interoperability testing is supported.
- **Web-based Customizable SDK:** Support automated on-demand SDK generation for different M2M use cases and various user requirements.
- **Flexible SCL and Application APIs:** Supports modular design and allows for use of different application protocols (CoAP, HTTP, and other protocols) and different implementations (of these protocols) without rework;
 - SCL SW platform: includes source and binary packages for M2M Devices, M2M Gateways, and M2M Servers;
 - SCL Primitive API: SCL primitive API is available in source and binary packages;
 - CoAP API: CoAP API is available in source and binary packages;

Going forward, InterDigital's M2MSDP will incorporate context-aware design, collaborative and cognitive networking, and cloud-based services to smoothly evolve into future Internet-of-Things (IoT), facilitating global networking of connected devices in a RESTful and more efficient fashion.

1.1 1. Standard End-to-End Solution

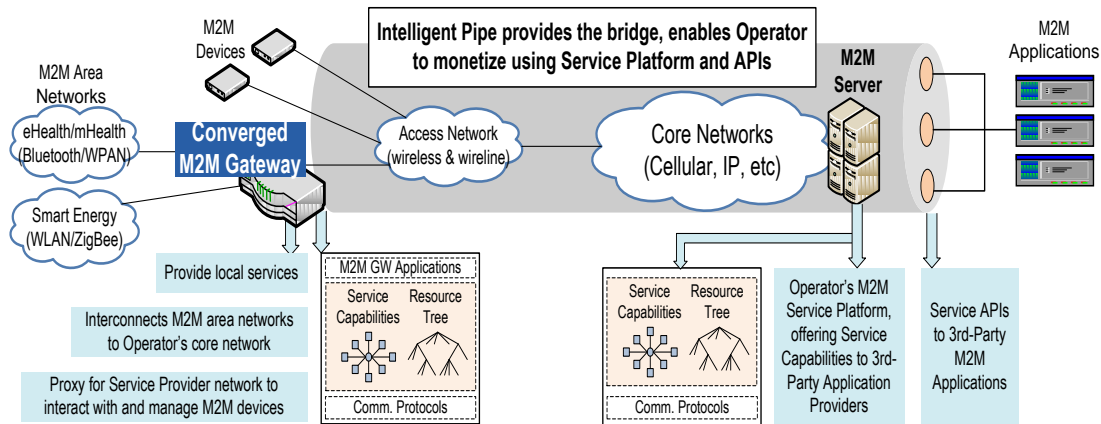


Figure 1: Standard End-to-End Solution

The E2E IP-based architecture provides a complete solution, including M2M Devices, Converged M2M Gateway, M2M Server, and M2M Application API. The M2M Server – the primary component of a provider’s M2M platform – offers M2M SCs to third-party M2M application providers via M2M Application API, which expedites application development and facilitates application interoperability.

Furthermore, the Converged M2M Gateway provides more value-added features.

- Hierarchical integration of M2M SCs, allowing the functionality to reside closer to the involved entities, while at the same time enabling optimizations in both network signaling load and data storage
- Proxying for Network SCs and Network applications
- Reduced Access/Core Network Signaling Load
 - Device and network registration information can be mirrored, shared, and/or coordinated within the gateway’s Trusted Environment so as to alleviate network signaling load
- Efficient Management of Underlying Devices
 - More efficient scheduling of management of individual devices,
 - “Bulk” management of similar devices, reducing signaling in M2M area network and access/core networks
 - Protocol translation if M2M Area Network management protocol is different from management protocol on the network side
- Device History Tracking: Gateway is best located to store device history for potential tracking purposes. Information can also be used to monitor device compliance to agreed profiles and to generate fault management reports

- Security: Gateway permits group authentication, authorization, and registration, of M2M Area Network devices
 - Provides first level of “filtering to prevent interaction with access and core network
- Network Selection: Gateway enables the selection of the optimum access network for communication to network applications. Similarly gateway enables selection of optimum M2M Area Network parameters for communication to M2M devices

1.2 2. Scalable Service Platform

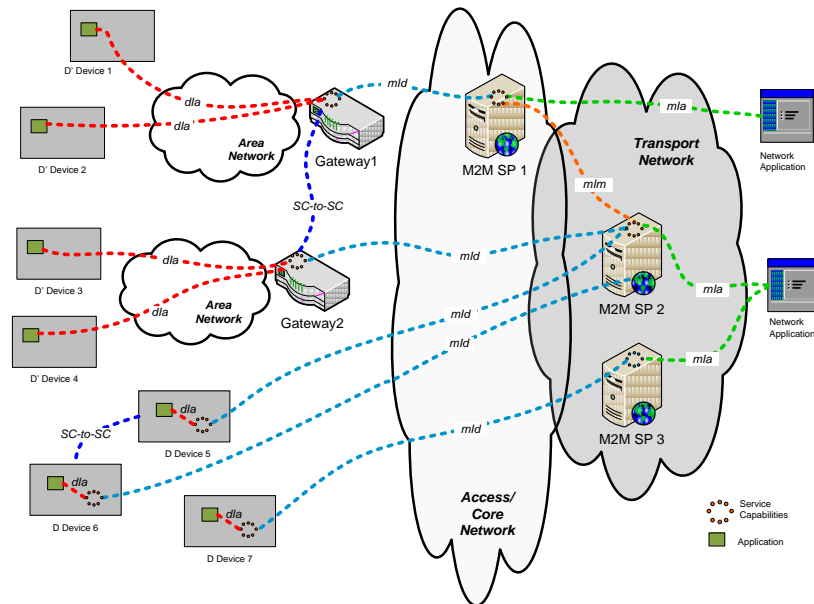


Figure 2: Scalable M2M Service Platform

The Scalable M2M Service Platform conforms to ETSI TC M2M Release 1 and Release 2 standards. It basically supports peer M2M Service Capabilities at M2M Devices, M2M Gateways, and M2M Servers. It also supports four M2M reference points: dla between an M2M Device/Gateway Application and an M2M Device/Gateway, mld between an M2M Device/Gateway and an M2M Server, mla between an M2M Network Applications and an M2M Server, and mlm between two M2M Servers. dla and mla provides uniform interfaces for M2M Applications. In addition, constrained M2M devices are supported as M2M Device Applications. Furthermore, the Scalable Service Platform is integrated with SC-to-SC interaction capabilities, which, as a unique feature, enables Device-to-Device ,Gateway-to-Gateway and Server-to-Server direct communications and in turn significantly improves system reliability, scalability, and overall performance.

In short, the Scalable M2M Service Platform supports the following features:

- Standard M2M Reference Points: dla, mld, mla, mlm;
- Standard M2M Service Capabilities for M2M Devices/Gateways/Servers;
- Supports two kinds of M2M Devices: Fully functional D-type devices with SCs and constrained D'-type devices without SCs;
- Direct SC-to-SC interactions and communications to improve reliability, scalability, and security;
- Network and application aware but agnostic.
- Configurable charging functionality
- Web-based software development kit (SDK)

1.3 3. Compatible Software Development Platform

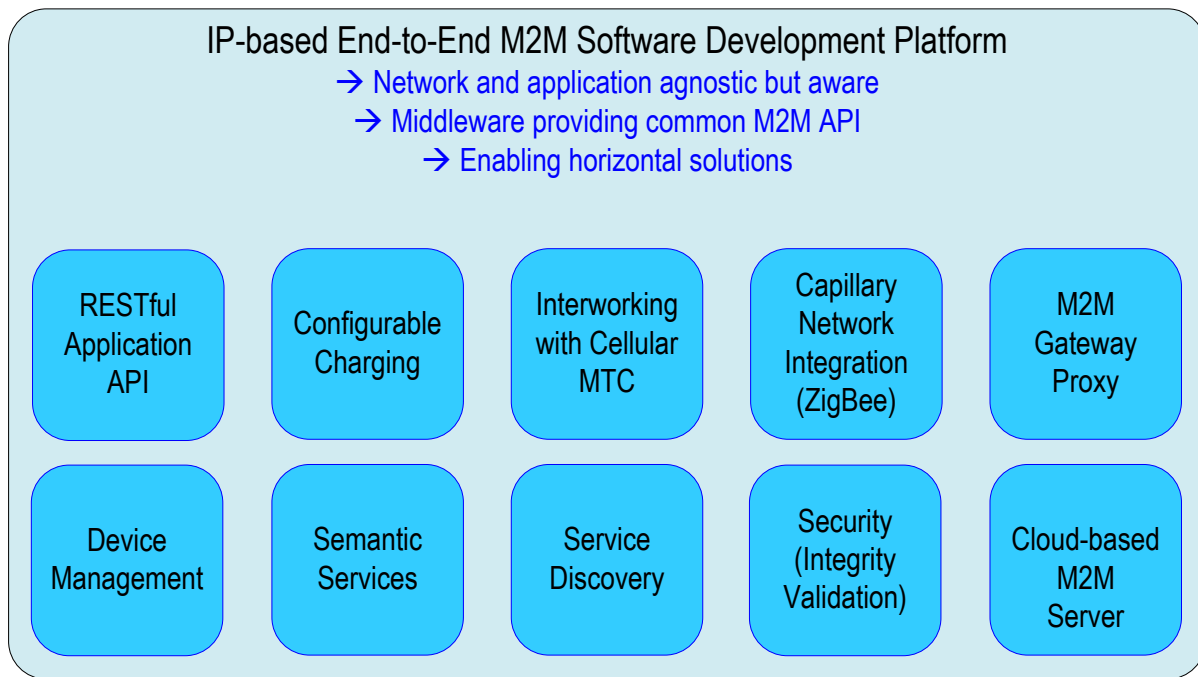


Figure 3: Compatible Software Development Platform

InterDigital's M2MSDP is aligned with standards – providing a platform to validate pre-developed solution – and promotes R&D activities. It incorporates M2M core technology development – including configurable charging, Interworking with cellular MTC, cloud-based M2M server, semantic services, device management, service discovery, security integration, RESTful application API, M2M Gateway proxy, and capillary network integration .

- Capillary Network Integration: Tunnel mechanism is designed on the service layer to enable scalable and efficient interworking between M2M service platform and different capillary network technologies such as ZigBee. The tunnel mechanism enables E2E communications to and between various capillary network at the service layer;
- Semantic Services: Supports cognitive, non-opaque data management including intelligent data process, mining and analytics to enable semantic data services at M2M service application layer;

1.4 4. RESTful Architecture

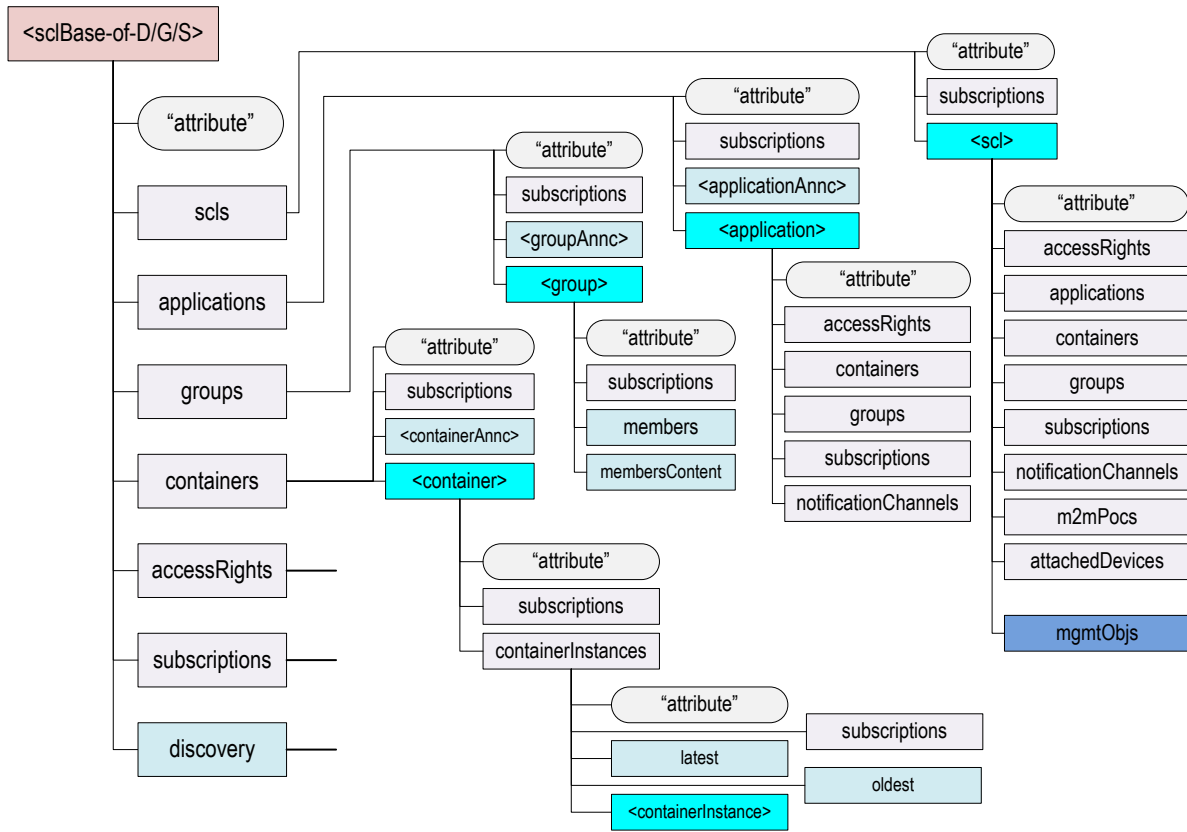


Figure 4: Hierarchical Resource Tree

RESTful architecture is based on a hierarchical resource tree and standard resource manipulation methods, including: CREATE/RETRIEVE/UPDATE/DELETE (i.e. CRUD). It provides the following advantages:

- RESTful architectures are stateless and based on Client/Server model and provides uniform interfaces;
- Clients initiate requests to servers. Servers process requests and return responses
- Requests and responses are built around the transfer of representations of resources. Resource are stored at the Server;
- Each resource can have “unique address”, “attributes”, and “sub-resources”.
- Each resource can be manipulated by Create/Retrieve/Update/Delete (CRUD) methods as well as Subscription.

1.5 5. Configurable Charging Architecture

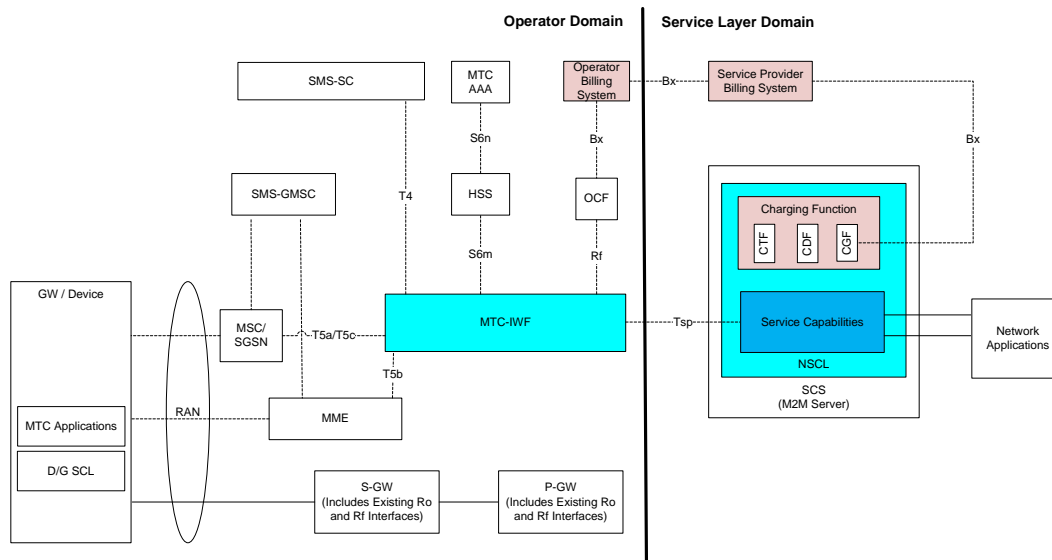


Figure 5: Configurable Charging Architecture

With a configurable charging architecture, the Service Capability Server (SCS) (e.g. an M2M Server) can access charging records generated within 3GPP networks as well as charging functions within 3GPP network can access and leverage charging records generated within the SCS (e.g. M2M Server). Both offline and online charging are supported. The following features are supported:

- Charging function in service domain supports Charging Trigger Function (CTF), Charging Data Function (CDF), and Charging Gateway Function (CGF)
- Standardized charging functions and protocols
 - Supports Diameter Server, Relay/Proxy/Redirect Agent, and Client
 - Supports Diameter Peer Discovery
 - Supports various protocol interfaces as specified in IETF, 3GPP, 3GPP2, and ETSI TISPAN IMS
 - Compliant with IETF standards including RFC 3588, RFC 3539, RFC 3589, and RFC 4006
 - Compliant with 3GPP specifications including TS 29.299, TS 29.329, TS 32.299, TS 29.209, and TS 29.272

1.6 6. Efficient Interworking with Cellular MTC

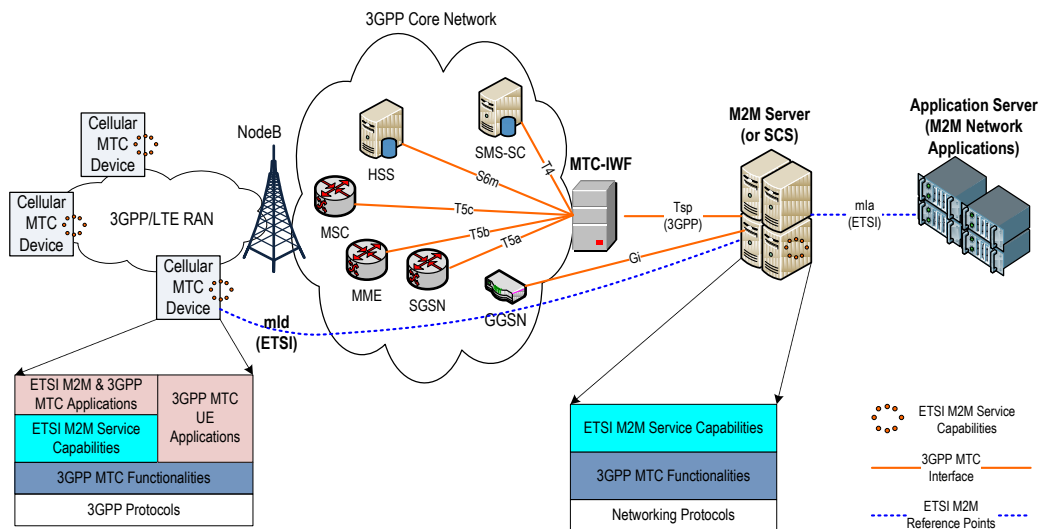


Figure 6: Interworking with 3GPP Cellular MTC

Efficient interworking with cellular MTC via interworking function (IWF) enables seamless integration of M2M SCL (e.g. ETSI M2M SCL and oneM2M) with cellular MTC devices. On one hand, M2M service capabilities can invoke and leverage cellular MTC functions to optimize and support better M2M services; on the other hand, cellular MTC functions can be furthermore enhanced for M2M service capabilities. InterDigital’s M2M solution supports 3GPP Release 11 and beyond for interfacing with an SCS (i.e. M2M Server) platform; it has the following features and advantages:

- MTC-IWF: acts as the sole interface on the control plane for interworking 3GPP core network and M2M service capability layer while hiding 3GPP core network details (e.g. topology) to service providers. The MTC-IWF supports:
 - Resolution and mapping of external MTC identifiers to internal identifiers;
 - Accepts device trigger requests from an M2M Server (or an SCS) and selects appropriate delivery methods to forward the requests to MTC devices via 3GPP network;
 - Charging records for delivered triggers
- Device Triggering: Allows online server-initiated device trigger for two purposes:
 - To send small amounts of MTC device application data from an SCS (i.e. an M2M Server) to an MTC device;
 - To instruct an MTC device application to initiate communications with an SCS (i.e. an M2M Server); thus requiring the MTC UE to obtain an IP address if it does not already have one.
- QoS Request: supports an SCS (i.e. an M2M Server) and/or an MTC to request different QoS requirements.

1.7 7. Lightweight Device Management

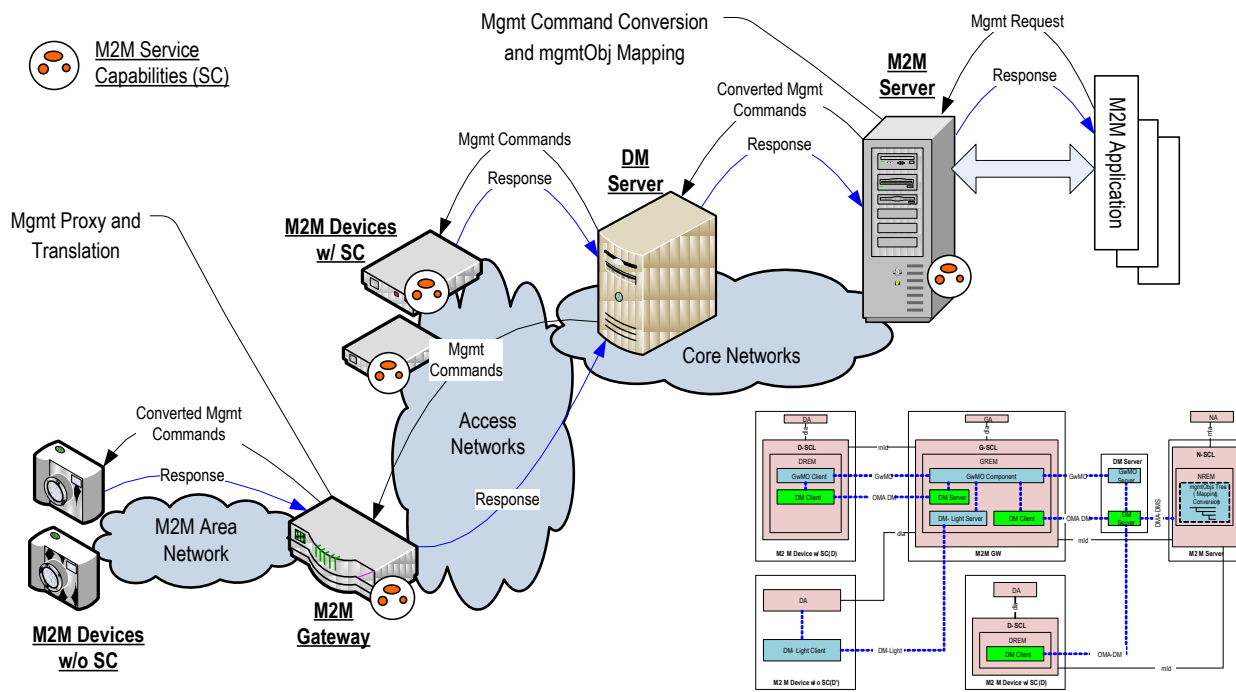


Figure 7: Device Management

Lightweight Device Management facilitates firmware/software management, fault management, configuration and performance management of a variety of M2M Devices including constrained M2M Devices and M2M Area Networks in a RESTful manner, especially via M2M Gateway to efficiently manage constrained M2M Devices behind an M2M Gateway. The traditional non-RESTful management commands are well supported modeled as RESTful operation at the M2M Server.

It helps operators and customers to efficiently deploy massive M2M Devices and diagnose and fix the problem quickly with greatly reduced management cost.

1.8 8. Automated Service Discovery

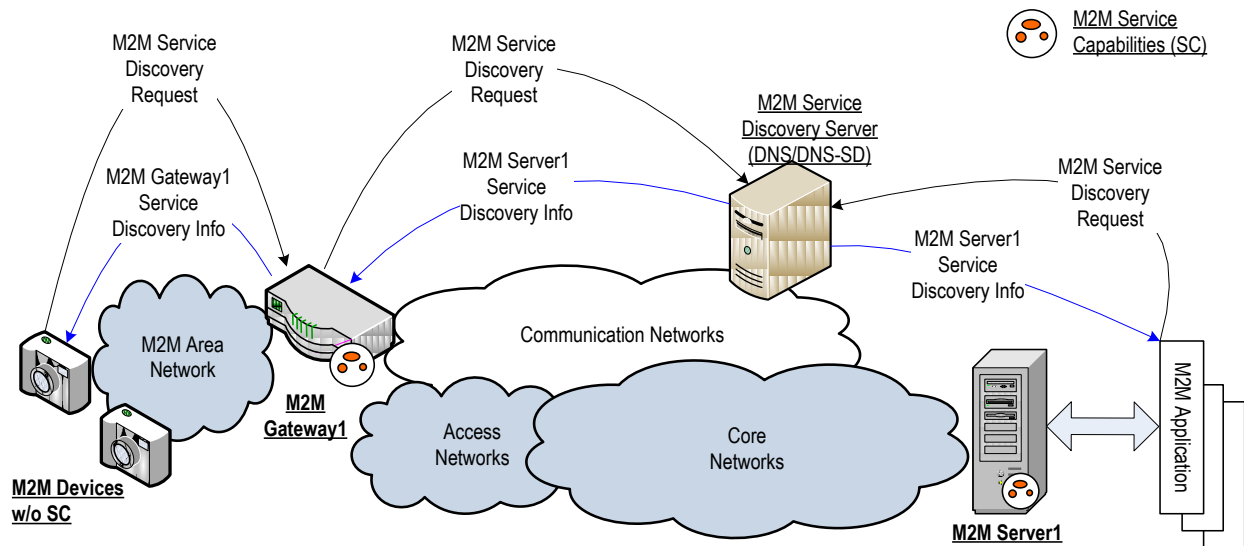


Figure 8: Service Discovery

Automated Service Discovery allows M2M SCs to be dynamically discovered, which is critical for M2M type devices that may have little or no human interaction. It supports:

- A light-weight automated SCL discovery procedure based on a well-known resource. This is excellent for situations where the network address of the M2M Server, Gateway, or Device to be targeted by the SCL discovery procedure is known in advance;
- An advanced procedure based on the definition of a new M2M Service Discovery Function (MSDF) which leverages the underlying concepts of the DNS-SD protocol to find available SCLs.

1.9 9. Autonomous Integrity Validation

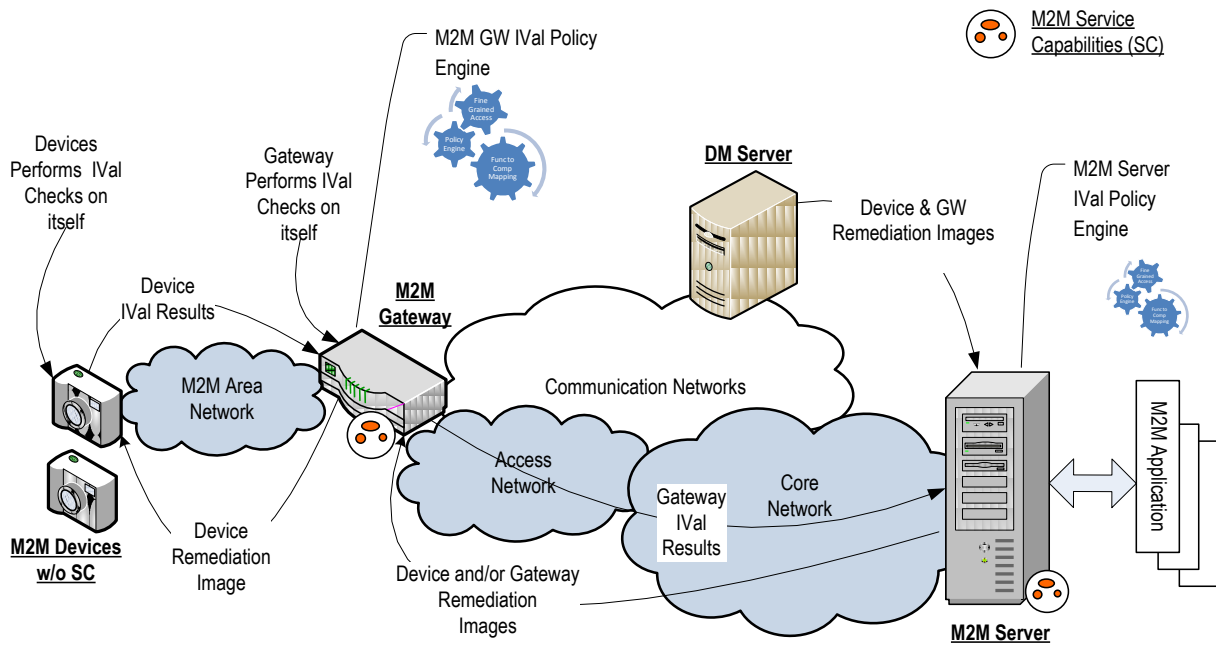


Figure 9: Autonomous Integrity Validation

Autonomous integrity validation enables M2M Service providers to get M2M Devices and M2M Gateways integrity information in a RESTful manner and fix them if there is any problems. Also M2M Application providers are able to validate M2M Device Applications and remediate failed applications. Autonomous integrity validation brings the following advantages:

- Increased protection of M2M Devices
- Fine grained access control
- Configurable policy engine
- Scalable to network edge devices
- Minimal overhead
- Software or Hardware based solution options
- Improved Reliability and Dependability

1.10 10. Flexible Service and Application APIs

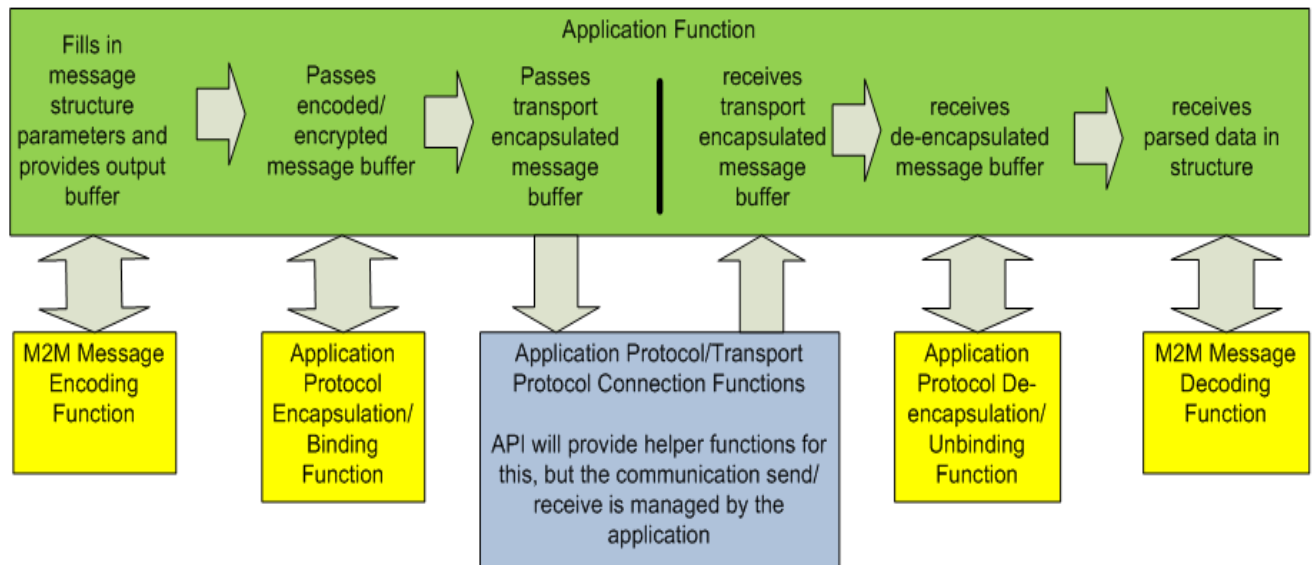


Figure 10: Flexible Application API

The M2M Application API is RESTful and highly flexible. It provides a uniform interface and facilitates quick M2M Application development. It supports both HTTP and CoAP protocols.

It has the following features:

- Provides a standard and easy-to-use interface for application developers
- Modular design allows for use of different application protocols (CoAP, HTTP, etc)
- Thin layer design ensures that the application has total control over operations including memory usage
- Small footprint and modular design supporting both resource constrained devices and fully featured machines

1.11 11. Interworking Proxy Unit for InterNetworking with Legacy M2M Networks

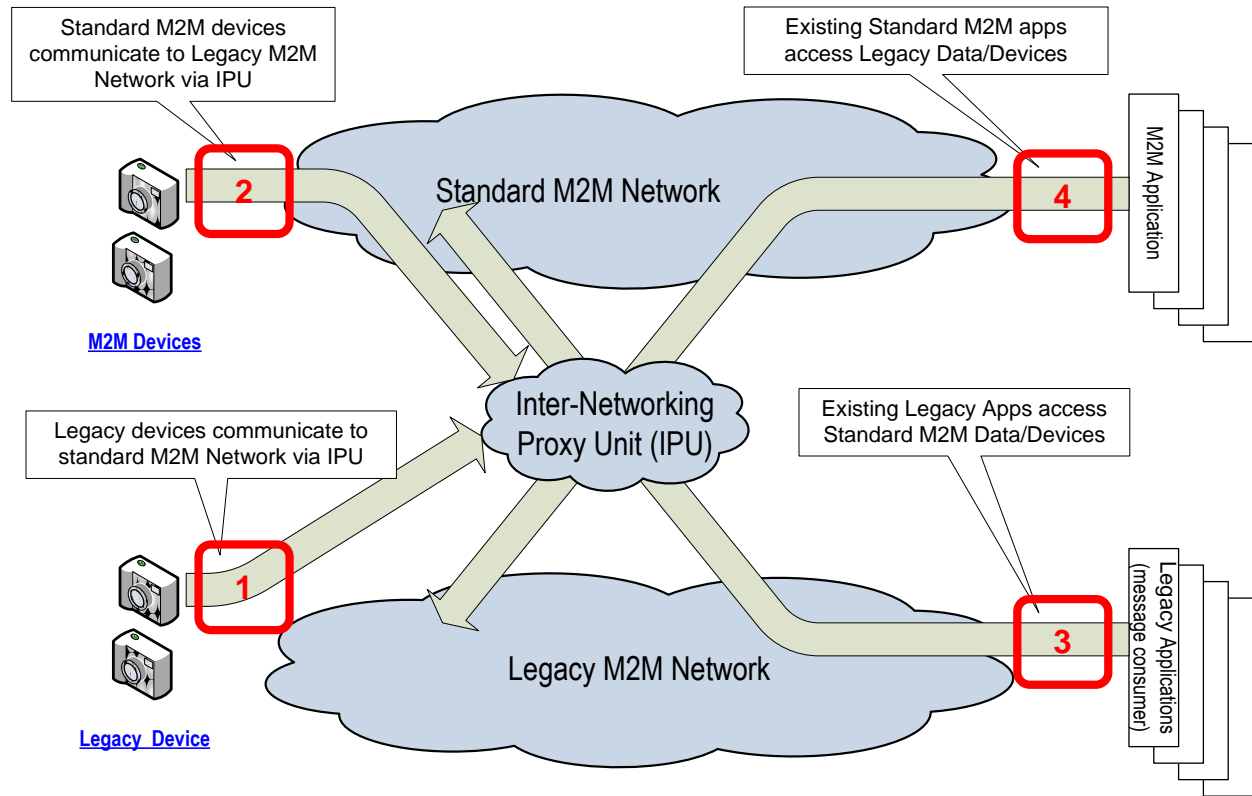
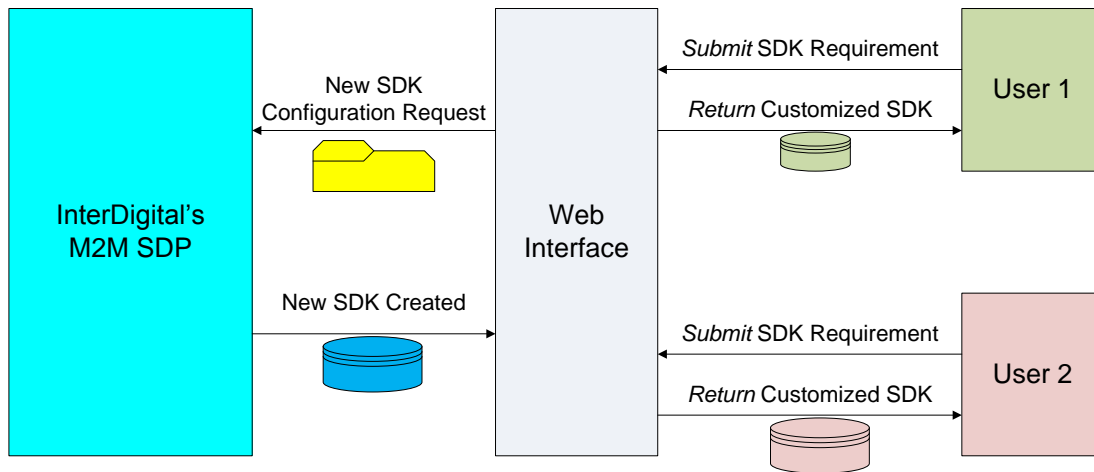


Figure 11: InterNetworking with Legacy M2M Network

InterDigital’s M2M SDP includes an intelligent Interworking Proxy Unit (IPU) to connect and convert existing or legacy service platforms into a standard-based platform without a complete overhaul. It enables data access and exchange between standard-based M2M network and legacy M2M network.

- IPU is implemented as a service capability of M2M Gateway or M2M Server.
- IPU enables
 - Standard M2M devices communicate to Legacy M2M Network via IPU
 - Existing Standard M2M apps access Legacy Data/Devices
 - Legacy devices communicate to standard M2M Network via IPU
 - Existing Legacy Apps access Standard M2M Data/Devices

1.12 12. Web-based Customizable SDK**Figure 12: Web-based Customizable SDK**

InterDigital's M2M SDP provides customizable SDK via GUI-based web interface. It satisfies different user requirements and enables automated on-demand SDK generation and customization. It features:

- Customized M2M SDK for different M2M use cases
- Customized M2M service capability APIs for M2M device, M2M gateway, and M2M server with a great number of options for users
 - OS/platform, SCL resource tree, binding protocols, SCL database platform, etc
- Customized M2M application APIs for different protocols (e.g. HTTP, CoAP)
- GUI-based web interface which provides great convenience for users
- Provides default SDK recommendation for users

1.13 13. Future Vision on IoT

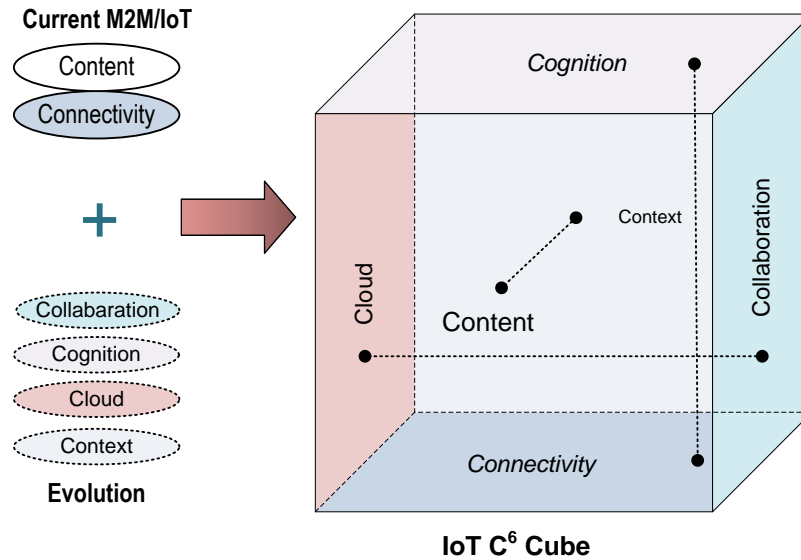


Figure 10: Future Vision of Internet of Things

Current M2M solutions are focused on communications (i.e. how information is transmitted from one machine to another). Evolution will effectively integrate “connectivity” and “content” with “context”, “collaboration”, “cloud”, and “cognition”. The future Internet of Things will be a global network of interconnected objects, enabling object identification/discovery and semantic data processing via C⁶

- **Connectivity:** connection for mobile and constrained objects;
- **Content:** massive data produced from things;
- **Cloud:** cloud service and cloud content storage;
- **Context:** context-aware design to improve performance;
- **Collaboration:** cooperative communications, inter-things, service sharing;
- **Cognition:** mine the knowledge from massive data and provide autonomous system adjustment for improvements.

InterDigital’s M2M SDP is incorporating advanced features: device-to-device (D2D) and/or peer-to-peer (P2P) proximity- based communications, and adaptive service provisioning via resource virtualization (i.e. XaaS). The M2M Server will be evolved into IoT Server with these advanced features integrated in.

1.14 Summary and Conclusion

The availability of lower cost devices, sensors, and actuators with increased computing and lower power has created a huge opportunity for growth in M2M Service Applications. To rapidly realize this growth potential requires faster time to market, lower costs, and re-use of applications within vertical applications and possibly across other markets.

Standards like ETSI TC M2M can help accelerate the development and re-use of service solutions. InterDigital's standards-compliant M2MSDP service platform provides a scalable IP-based End-to-End horizontal solution, enabling:

- M2M application developers to develop their applications more quickly and efficiently;
- M2M service operators to smoothly integrate different M2M applications and manage the whole M2M system with greatly reduced cost (CAPEX and OPEX);
- M2M device vendors to expand and improve their products with value-added features and interoperability with different devices.

InterDigital is focused on supporting the entire M2M eco-system by providing advanced wireless technologies for emerging M2M markets and the future Internet of Things.

About InterDigital®

InterDigital develops fundamental wireless technologies that are at the core of mobile devices, networks, and services worldwide. As a long-standing contributor to the evolution of the wireless industry, we solve many of the industry's most critical and complex technical challenges years ahead of market deployment. Our advanced solutions support more efficient wireless networks, a richer multimedia experience, and new mobile broadband capabilities. Accordingly, we have established licenses and strategic relationships with many of the world's leading wireless companies.

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