TI's Internet of Things (IoT) cloud ecosystem: what does it bring to developers?

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TI's diverse Internet of Things (IoT) cloud ecosystem features more than 30 partners and is a key enabler for customers looking to develop IoT applications.

As a relatively young and rapidly evolving market, with clear leaders yet to emerge among platform providers, it is important that TI provide its customers with a wide range of cloud solutions. These relationships are particularly critical when providing software ports or other related collateral that enable customers to get started quickly and easily.

Diversity of IoT solutions

Clear, recognized standards (e.g. the Linux operating system) already exist in mature markets such as communication and video equipment. And to ensure developers are able to meet these standards, TI provides both Linux ports and application-specific libraries to help customers quickly begin development.

However, even though TI provides prepackaged support for several IoT platforms, these offerings only address part of a given market due to the inherent fragmentation found in emerging technologies. Because IoT applications are dependent on so many components working together, developers will inevitably need to combine multiple product offerings to deliver a complete solution. Fortunately, TI allows its customers to choose solutions that best fit their needs by working with a variety of companies that provide a broad range of IoT platform solutions.

Key considerations when choosing an IoT platform provider for your next IoT project

Major cloud computing platforms: Over the last few years, several large cloud computing platforms have emerged, including Amazon Web Services (AWS), Microsoft Azure, Google Cloud Platform and IBM Bluemix. These solutions initially gained significant traction as large server farms to run established IT applications.

However, they are now offering Software-as-a-Service (SaaS) environments that provide customers the flexibility to select a range of standard services, including IoT-related ones. These IoT platforms (AWS IoT, Watson IoT, Azure IoT) may be attractive for customers who prefer to extend this service out of an existing cloud environment.

End-to-end IoT Platforms: A major challenge for the IoT is unifying highly disparate technologies – cloud computing, mobile applications, wireless connectivity and deeply embedded devices. This complexity creates a significant barrier for companies looking to initiate IoT projects as one organization rarely understands all aspects of the implementation.

For companies who prefer to use one provider for implementation, attractive alternatives include Xively, Arrayent or Exosite – who all have vertically-integrated, customizable IoT platforms to create turnkey solutions. These providers also typically complement their platforms with professional service teams to help developers design and deploy their solution.

Flexible hosting solutions: IoT services offered by the major cloud computing companies are unsurprisingly tied to their respective cloud platforms. While this will not present an issue for customers who have already invested in a specific cloud platform, others may desire a different approach.

Many smaller vendor solutions are also compatible with major cloud platforms, allowing the flexibility to choose your preferred host. For example, Exosite offers an IoT platform that may be hosted on AWS or Azure. Exosite and many others also offer 'private' platforms that may be installed on customers' "on-premise" servers. This approach is preferred for those who wish to have complete control of security measures.

Integration with other cloud services and ecosystems: IoT applications offer a significant opportunity to capture large amounts of data. However, to justify the investment, this information will need to be organized and analyzed in a meaningful way. Typically the principal consumers of the information will use a customer relationship management (CRM) application (or a CRM equivalent), not the IoT platform itself.

Therefore, it is important that the platform be integrated with appropriate downstream services such as analytics platforms. As an example, Xively not only hosts its IoT platform on AWS but also provides an integration layer to easily access many AWS services, additional analytics and CRM platforms like Salesforce. This enables customers to fully leverage the new data they are gathering.

Security: Security has long been a major concern for the IoT. Nobody wants an unauthorized user to open their connected door lock. Fortunately, nearly all vendors offer secure device-to-cloud communication for telemetry, certificate management and firmware updates using TLS. Some vendors also offer enhanced certificate security through advanced features such as Online Certificate Status Protocol (OCSP) stapling.

Another, sometimes overlooked, consideration is end user access control, especially when administering an IoT application that features hundreds or thousands of nodes. Rather than making the entire set accessible, you will likely want to limit node access to specific nodes or classes of nodes for each user, rather than allowing all devices to be visible for any user.

Business model: Proposed IoT applications may require a cost-benefit analysis prior to implementation and deployment – with a key consideration being the potential cost of the platform. Some IoT solutions, including the major cloud platforms, offer a subscription model based on the volume of message traffic between the cloud and end devices.

While this approach is acceptable for many applications, a connected smoke alarm system customer, who might expect very little volume of traffic, may not want to pay a recurring subscription. In this case, a one-time fixed charge per device might be more appropriate.

A private, on-premise cloud will also offer different pricing options by eliminating per-device costs. In this case, customers simply license the core IoT platform under an annual subscription or one time license fee.

A less expensive alternative is for customers to use an open source IoT cloud platform such as Kaa or DeviceHive. These have no licensing or subscription fees since the companies backing them profit on development and support contracts.

A final, important point to consider is the cost associated with initial and sustaining development of an IoT application. While some companies may include development and maintenance work costs in the SaaS fee, others will require you to maintain your own development resources.

Connectivity choices: Most IoT application starter kits emphasize Wi-Fi® connectivity since it enables a direct cloud connection for endpoints. Wi-Fi is

an excellent solution for many applications due to its connectivity, reasonable range and high data throughput.

However, IoT endpoints that require ultra-long battery life, ultra-low cost or very long range may be better suited to other wireless technologies, which typically require gateways with a cloud connection. TI can provide a wide range of wireless connectivity solutions as a customer makes this decision, but choosing a cloud vendor with gateway expertise and evaluation options for multiple wireless technologies will also be a very important consideration.

Mobile applications: IoT devices commonly use mobile applications (apps) as the primary human interface, making its functionality a critical factor in creating a successful platform. Therefore, you will need access to mobile app development resources. If you are designing a 'mobile IoT' app, where a mobile device directly interfaces with an IoT endpoint, designs can become much more complex.

Properly connecting to the cloud requires apps to manage *Bluetooth*® low evergy connections and even act as a cellular or Wi-Fi gateway for the endpoint. In these cases, an IoT-specific mobile app SDK (similar to those available from Evothings) may serve as a valuable resource during app development.

Getting Started

Once customers have identified an IoT solution(s) to evaluate for their application and have put together initial specifications, the next step is developing a prototype. The TI LaunchPad™ development kit ecosystem and BeagleBone, a development platform for Sitara™ processors, community offer a growing selection of boards that allow developers to begin prototyping applications without designing or creating hardware themselves.

Browse TI's Cloud Solutions page to find providers who have pre-integrated their IoT solution with one or more TI kits. This pre-integrated cloud connectivity enables customers to immediately focus on development and is especially useful for the following reasons:

- Developers with a cloud computing background aren't typically familiar with the software needed to connect embedded hardware platforms to IoT services. In fact, they may not even be familiar with C programming, which is essential for embedded software development.

Conversely, embedded software developers typically lack experience implementing applications using cloud-based services. Having pre-ported software that enables the board to connect to the cloud enables both cloud application developers and embedded developers to get started immediately without having to first become experts in each other's domain.

- Even with a detailed outline, simply getting started is often a challenge. The process involves installing a minimum of two SDKs on the embedded side (the embedded SW tools for the chosen board and the cloud platform's agent SDK) and downloading a security certificate for the device. Having board-specific recipes reduces the possibility of developers making mistakes during the process.
- In addition to basic telemetry, many IoT platforms' device management features (e.g. over-the-air (OTA) firmware updates) can introduce new hardware dependencies such as the need to write to flash to update the firmware image. Having features like OTA out-of-the-box allows the customer to focus on differentiating their application rather than implementing low-level details.

- Although cloud connectivity is not a differentiator for IoT applications, the underlying technology used for the cloud-endpoint connection is often critical. The choice of wireless connectivity has a significant impact on endpoint cost, battery life, data rates and range:
- Wi-Fi: While Wi-Fi-enabled endpoints can connect directly to the cloud, this method is more expensive and power-hungry than other technologies.
- *Bluetooth* low energy, Sub-1 GHz or IEEE 802.15.4: For applications with low data rates, it may be more cost-effective to use one of these technologies. Endpoints using these protocols must use a gateway to connect to the cloud.

To make the selection process easier, TI and its partners work together to provide the necessary software or recipe for each connectivity solution. This white paper serves as a great resource to learn more about which radio technology is most appropriate for your application.

Summary

IoT technologies are still relatively young and constantly evolving, with many vendors offering varied solutions. TI's IoT ecosystem allows our customers to select the best technology for their needs from a broad range of platforms and related solutions. By combining embedded processors or microcontrollers with connectivity and sensing, TI is uniquely positioned to offer a range of evaluation boards that serve as a great starting point for developing IoT applications; and our partners make the process even easier by providing pre-ported support for IoT agents to these boards.

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