IIJ launched a new wireless data communication service for consumers in February 2012 as a Mobile Virtual Network Operator (MVNO) using the NTT DOCOMO LTE network. The most striking feature of this service is its unique plans, which mix pay-as-you-go and flat rates. Ordinary flat-rate plans cause many light users to bear the heavy equipment costs incurred by a small number of heavy users. Now we can provide a reasonable service to customers who do not like viewing video content over mobile devices, or who do not send/receive large files frequently.

We built an advanced charging system for these new plans, called the Online Charging system. For the ordinary method of charging, called Offline Charging, the user is billed after the fact at the end of each month based on the amount of packets used, which is essentially batch processing. In an Online Charging situation, the amount of data that can be used (the data cap) is determined in advance. The amount remaining until the data cap is hit is calculated in real time, and service is promptly suspended after reaching the cap. This could be compared to pay phones, with the only difference perhaps being that for online charging the system for managing the amount of usage remaining is implemented on the network side, unlike pay phones where this is handled on the device side (pay phone equipment).

The 3GPP project for the standardization of mobile phone technology is responsible for standardizing online charging specifications. Figure 1 shows the PCC (Policy and Charging Control) system architecture established by 3GPP.

The S-GW (Serving Gateway) and the area to the left of the S-GW is not our equipment, but the equipment of the MNO, NTT DOCOMO. A MVNO does not need to operate its own P-GW (PDN Gateway), but we operate a P-GW on our own account. The P-GW is quite expensive and hard to operate, but operating our own P-GW gives us the opportunity to implement initiatives such as these new plans (for which there are few other examples around the world).

First, we selected a P-GW that supported PCC and featured the PCEF add-on. PCEF is a network device that coordinates with the other two subsystems, OCS and PCRF, to apply the necessary policy to data flow that passes through the P-GW. For example, policies are applied to specified data flow that passes through the PCEF indicating whether it is high speed or low speed.

Next, the OCS manages the data caps defined for each customer. We refer to these data caps as coupons. The OCS cooperates with the PCEF to calculate and store customers' remaining coupon amount continuously. On the other hand, the PCRF determines the policies for each customer. It coordinates with the OCS to apply the low-speed policy to customers who have used up all their coupons, and the high-speed policy to customers who are granted coupons at the beginning of the next month, or who purchase additional coupons. Once this is determined, it sends the appropriate message to the PCEF.

Our pricing plans are established through the cooperation of these three subsystems. The P-GW/PCEF is an off-the-shelf network device, but the OCS and PCRF were developed almost entirely by IIJ (with only the Diameter server they are based on being an off-the-shelf product). We believe that in-house development of the OCS and PCRF, for which there is very little in the way of existing implementations, documentation, or products, enabled us to provide an extremely unique pricing plan ahead of the rest of the world.

One method for switching policies without using PCC is to change the APN (access point name, a string for identifying the access point). This method involves preparing multiple APN, such as separate ones for high-speed and low-speed, and switching by disconnecting devices from the network and then reconnecting to the other APN. This has the slight advantage of reducing costs and operational load by eliminating the need for PCC-related systems. However, because devices must
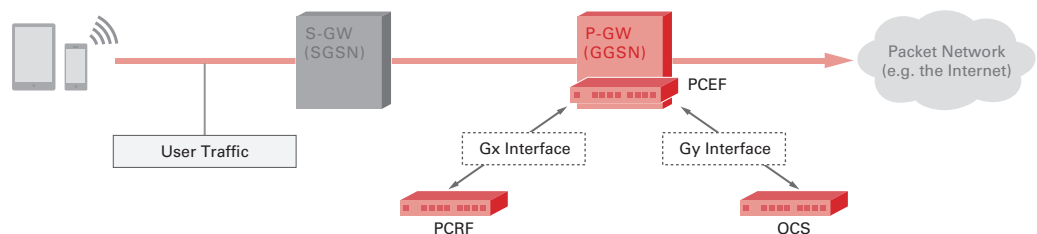
PCC Subsystem Name		Characteristics
OCS	Online Charging System	• Monitors the volume of customer traffic in real time • A "valve" triggered for devices that have carried out a predetermined amount of traffic
PCRF	Policy and Charging Rules Function	• Manages the policies applied to customer in real time • Coordinates with the OCS to determine policies for each customer in real time
PCEF	Policy and Charging Enforcement Function	• A network device that cooperates with the OCS and PCRF to apply policies for each customer

Figure 1: PCC (Policy and Charging Control) System Architecture Established by 3GPP

be disconnected when switching policies, for customers it has the disadvantage of interrupting communications, forcing them to wait while the policy is switched and communications resumed. In contrast, IIJmio's PCC implementation makes it possible to switch policies while maintaining connections (without interrupting communications) through the use of PCEF. We believe this is a superior method that causes less stress when switching speeds.

■ **The mioPON IIJmio Coupon Switch App**
When the IIJmio High-Speed Mobile/D Service was launched, there was no function for actively switching communication speed. Instead, only simple controls were in place, with high-speed communication service provided as long as coupons remained, and low-speed communication service provided when coupons were exhausted. Later, in response to requests from customers, we looked into providing a function that made it possible for customers to transition to low-speed communications at their discretion even if they still had coupons left (Figure 2).

No significant changes to the PCC were required, but considering many IIJmio users use smartphones or tablets, we foresaw ample demand for an app that switches coupons. As a result, we worked on development for app-based switching.

The Coupon Switch app requires the following functions.

• Draw and execute the UI for switching coupons ON/OFF
• Execute the WebAPI for collecting the line information for the target of the operation and switching coupons ON/OFF
• A mechanism for sending the ID and password to verify the user is an IIJmio subscriber, and acquiring an access token for the WebAPI

We implemented these functions in HTML5 to perform cross-platform development for iOS and Android. We developed this app entirely in-house. Improving our technological capabilities in developing mobile apps provided the benefit of making it easy to expand functionality and polish the UI.

Additionally, because usability that facilitates stress-free execution and operation is of utmost importance for the Coupon Switch app, we kept the number of functions to the bare minimum, and implemented a simple UI that can be used intuitively (Figure 3). Coupled with the fast, seamless speed switching of our PCEF, this enables speed switching to be carried out extremely smoothly. The "mioPON" app is used on a daily basis by many customers, reaching an installed base of 30,000 (Android/iOS total) three months after its release, and earning favorable ratings of 4.5 stars or higher in the App Store and the Google Play Store.

■ **Conclusion**
We believe the IIJmio High-Speed Mobile/D Service is a truly epoch-making solution, as an MVNO that introduces a new pricing plan with no other precedent at existing mobile telecommunications carriers. Since the launch of the service in February 2012, we have steadily continued to expand its features and make improvements. The flexibility of the PCC and other systems built by IIJ has contributed greatly to this. We will continue to engage in new endeavors to provide solutions for our many customers.
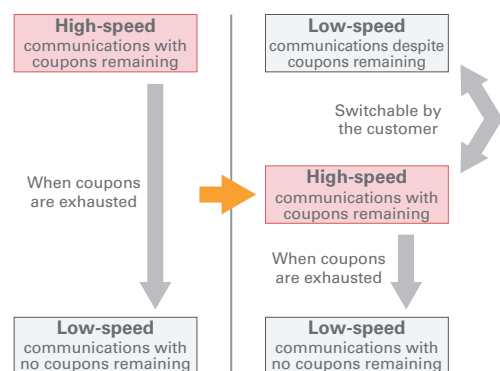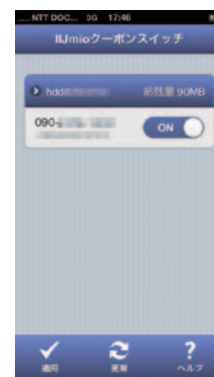
Figure 2: State Transitions via Coupon Switch App

Figure 3: Operation Screen of the Coupon Switch App

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