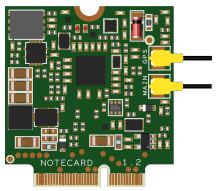
NOTECARD™

Device-to-Cloud Data Pump

Low-cost embeddable module for low-power embedded cellular connectivity



Most all types of commercial equipment must now either be designed from the outset, or retrofitted after-the-fact, to securely send data to the cloud. Some of these devices must also be designed for remote control.

The growing danger of connecting devices to the internet using WiFi, combined with the increasing need to track assets while in-motion, has generated tremendous interest in cellular as an alternative for safe and reliable transport of data between devices and the cloud.

To date, however, cellular communications has been equated with high cost, high power, and high implementation complexity for hardware and software developers alike.

Notecard

As an embeddable device-to-cloud data pump, Notecard eliminates all complexity and friction that exists between the device and cloud. It enables development and rapid iteration of production-quality secure cellular IoT solutions at an extremely low, fixed cost. With as little as two lines of code on the controlling MCU, and with no external libraries or dependencies, data can be sent from device to cloud. Notecard is

- A drop-in embeddable data storage and transport module for cellular data transport, pumping JSON-formatted or binary data (“notes”) bi-directionally between device and cloud
    - JSON from/to MCU application using I2C, Serial, or USB
    - JSON to/from your cloud app using HTTPS
    - JSON is auto-tagged with date/time, Tower and GPS locations, for tracking
- Embedded 10-year global cellular service, with 500MB or more of data. No SIM or carrier subscription required.
- Supports any MCU as your app processor - even low-memory 8-bit microcontrollers
- Low-power (8uA typical while active)
- Removable 30mm x 32mm system-on-a-module (SOM)
- TLS comms using integrated secure element and factory-installed ECC P-384 certificate
- Mostly-offline data sync mode for low power; always-online mode for low latency
- Data routing and simple “no code / low code” visual data stream analysis (Grafana, ML) through Notehub (SaaS), or integrate Notehub functions into your own app (OSS)

FEATURES

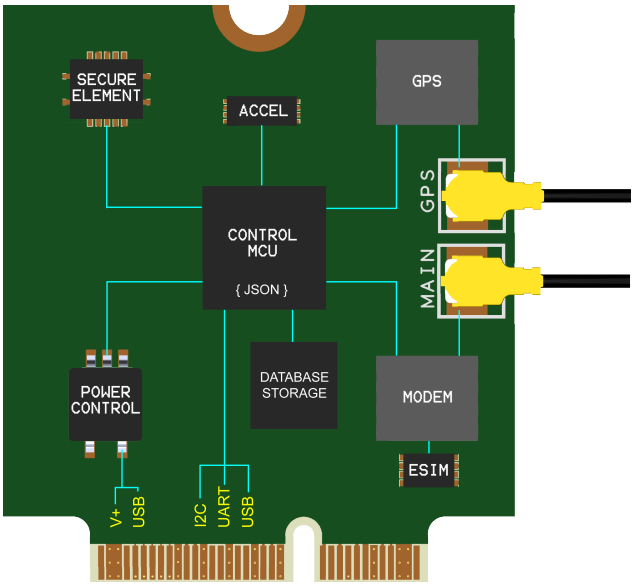
- Integrated modem. North American modem is LTE Cat-M1; Global modem is tri-band LTE Cat-M1, LTE Cat-NB1, and GSM. For areas where MIMO antennas will yield the best coverage, LTE Cat-1 support is also available.
- Integrated eSIM with both North American and Global coverage options. Includes 500MB of data on a 10-year coverage plan, with more available. No carrier subscription needed.
- Integrated GPS with accelerometer, for power-optimized location/motion awareness.
- Integrated Secure Element with hardware crypto, true hardware random number generator, and ECC P-384 certificate provisioned at chip manufacture.
- Simple JSON command interface with your choice of using I2C, UART, or USB to connect with your 3v3 or 1v8 MCU. No complex AT commands; no complex state to manage.
- Power management enabling the device to operate on battery power. Designed to be always-on while maintaining time & location, typically drawing less than 8µA when idle.
- Connectivity without the hassle of dealing with SSIDs, passwords, access points, gateways, carriers, or SIMs.
- Security without any provisioning challenges, with encrypted “off the internet” comms available
- Battery-powered (µA) cellular without the complexity of managing modems, connections, queues, or storage.
- Engineer-friendly choice of I2C, Serial, and USB request/response interfaces, and developer-friendly use of highly straightforward JSON request/response interface
- An extremely thin IaaS that directly routes your data to where it belongs: AWS, Azure, GCS, or your own cloud.
- Low barriers at all skill levels; few moving parts. A design that both hardware and software developers will love.

BLOCK DIAGRAM

Notecard is packaged using a compact removable form factor, 30mm x 34mm. Open hardware schematics available making it a straightforward task to embed the Notecard into a broad variety of host device designs

Notecard has an embedded SIM that enables its embedded cellular service coverage, with an integrated external SIM switch for applications that require such a capability.

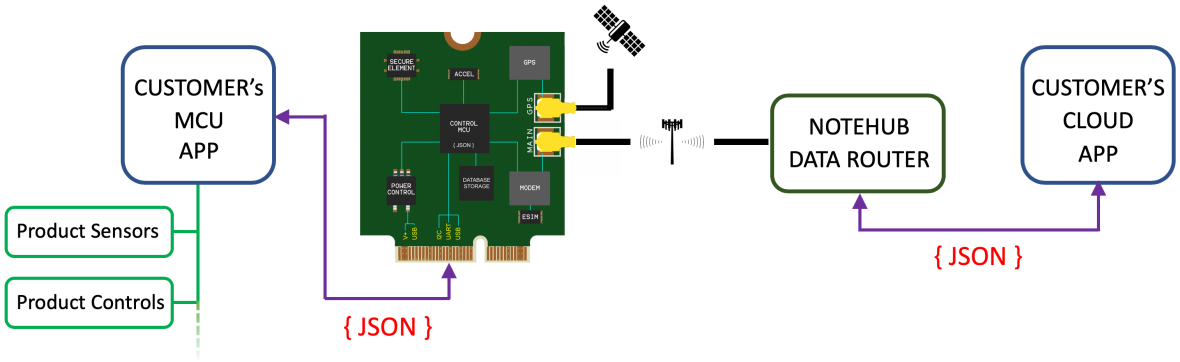
Notecard can interface with the host MCU at either 1.8v or 3.3v levels.



HOST MICROCONTROLLER API

Notecard supports an extremely rich, simple API whose syntax is standard JSON. The developer can use the I2C bus or the serial UART or USB interfaces to communicate requests to Notecard, generally by using little more than *printf* function available in most programming languages.

TYPICAL APPLICATION



As shown, Notecard is not an application processor and hosts no customer application code. It's a data pump peripheral that is focused on bidirectional, asynchronous, secure data staging and transfer of JSON *notes*.

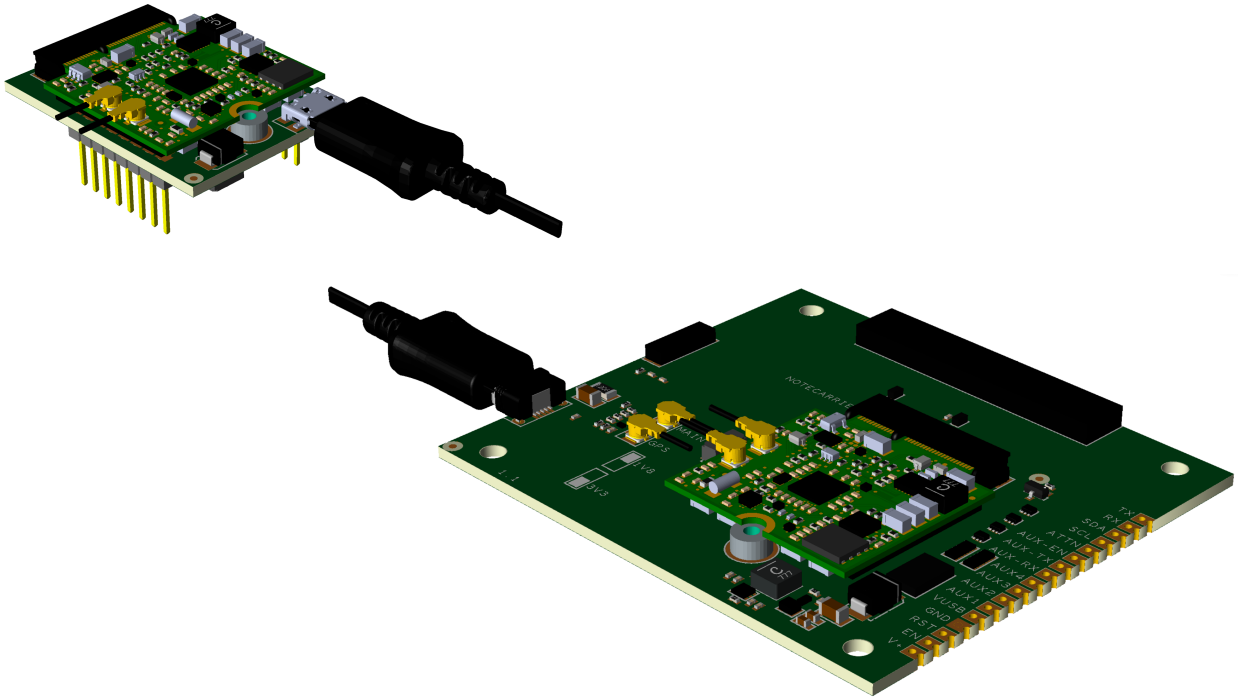
Tracking - Notes transferred by Notecard are tagged with time and location. Location is obtained using a GPS receiver, and time is available from both the cellular network and GPS. To optimize energy use in devices when not in motion, Notecard has a MEMS-based accelerometer that determines when use of the GPS is not required.

Security - Modern services require that the cloud and the device perform bidirectional authentication so that neither can be spoofed. For many applications it's important that over-the-air and over-the-wire data is encrypted. For this reason, Notecard integrates an STSAFE-A100 Secure Element which contains symmetric keys manufactured into the chip. Neither the manufacturer of Notecard nor the manufacturer of the customer's product has any need to handle or manage secure key material. The keys generated by STMicroelectronics for Notecard use ECC with the NIST P-384 curve, and the signature algorithm is ECDSA-with-SHA384.

Energy – Notecard has sophisticated power control and makes heavy use of variable clock speeds. The modem draws significant current when transmitting or receiving, the GPS when receiving, the CPU when doing session encryption, and even the Secure Element draws constant power when enabled to prevent certain side-channel attacks. No single switch in Notecard design has an Iq > 1µA. When coupled with its ability to run the I2C, UART, and RTC when the processor is STOP mode, Notecard draws less than 8µA at 3v3 when idle.

NOTECARRIERS

Notecard is designed to be placed directly onto the circuit board along with a customer's MCU, sensors, and controls. In addition, a variety of Notecarrier boards are available. They enable rapid prototyping and can be soldered directly onto a board for low-volume production. Some are designed for size optimization and others have integrated LTE and GNSS antennas.



CELLULAR SERVICE

A pre-activated 10-year data plan with 500MB of cellular data is embedded in Notecard, with more available for applications requiring it. No other actions related to cellular activation or deactivation are required. There are no “know your customer” restrictions, so Notecard can be embedded in a product without knowing the ultimate end-customer. Placement of a product can be permanent. Although global coverage area may change from time to time because of local technical and regulatory restrictions, global coverage currently includes:

Afghanistan
Albania
Anguilla
Antigua & Barbuda
Argentina
Armenia
Aruba
Australia
Austria
Azerbaijan
Bahamas
Bangladesh
Barbados
Belarus
Belgium
Belize
Bermuda
Bolivia
Bosnia Herzegovina
Bulgaria
Burkina Faso
Cambodia
Cameroun
Canada
Cayman Islands
Chad
Chile
Colombia
Costa Rica
Cote D'ivoire
Croatia
Curacao (Netherlands Antilles)
Cyprus
Czech Republic
Denmark
Dominica
Dominican Republic
Dutch Antilles
Ecuador
El Salvador
Equatorial Guinea
Estonia
Faroe Islands
Fiji
Finland
France
Gabon
Georgia
Germany
Ghana
Greece
Greenland
Grenada
Guam
Guatemala
Guernsey
Guinea
Haiti
Honduras
Hong Kong
Hungary
Iceland
Indonesia
Ireland
Israel
Italy
Jamaica
Japan
Jordan
Kazakhstan
Kenya
Kyrgyz Republic
Laos
Latvia
Lesotho
Liechtenstein
Lithuania
Luxembourg
Macau
Macedonia
Malawi
Malaysia
Mali
Malta
Mexico
Moldova, Republic Of
Mongolia
Montenegro
Montserrat
Morocco
Mozambique
Nepal
Netherlands
New Zealand
Nicaragua
Niger
Norway
Palestine
Panama
Paraguay
Peru
Poland
Portugal
Puerto Rico
Reunion
Romania
Rwanda
Serbia
Seychelles
Sierra Leone
Singapore
Slovakia
Slovenia
South Africa
Spain
Sri Lanka
St Kitts & Nevis
St Lucia
St Vincent & Grenadines
Suriname
Sweden
Switzerland
Taiwan
Tajikistan
Tanzania
Thailand
Trinidad & Tobago
Turks & Caicos
Uganda
Ukraine
UK Mainland
United States
Uruguay
Uzbekistan
Virgin Islands, British
Zambia
Zimbabwe

These countries are not included and require use of a user-supplied external SIM:

Bahrain
Brazil
China
Egypt
India
Iraq
Kuwait
Nigeria
Oman
Pakistan
Philippines
Russia
Qatar
Saudi Arabia
South Korea
Turkey
UAE
Venezuela
Vietnam
Yemen

NOTECARRIER HEADER PINOUTS

LABEL	DIRECTION	USAGE
V+	IN	2.5-5.5V, <8uA idle, <500mA typical, 2A surge max (GPRS)
GND	IN	
EN	IN	>1.1v will power on the module, used for main product ON/OFF and for when product is being shipped to ensure that there is no communications attempted. If USB is active as power source, this pin is ignored, else it is required to be tied high or low.
RST	IN	>0.8v pulse will cause hard-reset of the module. This pin is internally pulled low, so NC is acceptable.
RX	IN	Request Interface. Always configured for 9600/8/N/1.
TX	OUT	
SCL	IN/OUT	Request Interface. I2C Slave Address 0x17 (reconfigurable over USB or UART).
SDA	IN/OUT	
USB	IN/OUT	Request Interface. VID:0x30A4 PID:0x0001
VUSB	OUT	For engineering convenience, this is connected to the VUSB pin of the USB jack, and may optionally be used to power external peripherals, battery chargers, etc.
VIO	OUT	For engineering convenience, this is a reference voltage that indicates the selection of the 3.3v/1.8v switch. It can be useful to provide a reference to level shifters or other IO controls.
ATTN	OUT	A signal that may optionally be used by customer MCU to be notified of certain conditions, such as incoming data available from cloud service.
AUX-RX	IN	Provided to the developer for diagnostic purposes, so that they may learn by gaining greater visibility into what Notecard is doing at any given time. This port draws >100uA when enabled, and will only be activated if and when AUX-EN is pulled high.
AUX-TX	OUT	
AUX-EN	IN	
AUX1 - AUX4	IN/OUT	GPIO that is most commonly used by developers for debugging and tracing, or as simple command-driven inputs/outputs.

NOTECARD EDGE CONNECTOR PINOUT

Table 1: Notecard Pinout		
Pin #	**Pin Name**	**Functional Interface**
1	NC	--
3	GND	2. Power
5	GND	2. Power
7	USB_DP	3. USB Serial
9	USB_DM	3. USB Serial
11	GND	2. Power
13	VUSB	3. USB Serial
15	NC	--
17	NC	--
19	NC	--
21	NC	--
23	NC	--
Pins 25-31 are MODULE KEY		
33	GND	2. Power
35	NC	--
37	NC	--
39	GND	2. Power
41	NC	--
43	NC	--
45	GND	2. Power
47	NC	--
49	NC	--
51	GND	2. Power
53	NC	--
55	NC	--
57	GND	2. Power
59	NC	--
61	NC	--
63	NC	--
65	NC	--
67	NRST	10. Reset
69	NC	--
71	GND	2. Power
73	GND	2. Power
75	NC	--

Table 1: Notecard Pinout		
Pin #	**Pin Name**	**Functional Interface**
2	VIO_P	2. Power
4	VIO_P	2. Power
6	GND	2. Power
8	SIM_VCC	8. External SIM
10	SIM_RST	8. External SIM
12	SIM_IO	8. External SIM
14	SIM_CLK	8. External SIM
16	SIM_NPRESENT	8. External SIM
18	GND	2. Power
20	VACT_GPS_OUT	9. Active GPS
22	VACT_GPS_IN	9. Active GPS
Pins 24-30 are MODULE KEY		
32	NC	--
34	NC	--
36	NC	--
38	NC	--
40	SCL_P	5. I2C Serial
42	SDA_P	5. I2C Serial
44	NC	--
46	AUX1	7. Auxiliary Ports
48	AUX2	7. Auxiliary Ports
50	AUX3	7. Auxiliary Ports
52	AUX4	7. Auxiliary Ports
54	ATTN_P	6. Attention
56	AUX_EN_P	7. Auxiliary Ports
58	AUX_RX_P	7. Auxiliary Ports
60	AUX_TX_P	7. Auxiliary Ports
62	RX_P	4. UART Serial
64	TX_P	4. UART Serial
66	NC	--
68	NC	--
70	VMODEM_P	2. Power
72	VMODEM_P	2. Power
74	VMODEM_P	2. Power

Pins named "NC" MUST have no connection because they are reserved for future use. Those ending with _P are optionally protected from anomalous external conditions on some Notecarrier designs, depending upon use-case-specific requirements.

POWER

Notecard's main supply voltage (VMODEM_P) is used for the cellular modem and associated circuitry. Notecard has on-board regulators designed for direct connection to a LiPo battery, so any voltage in the range of 2.5V to 5.5V may be provided.

Although Notecard current draw is typically in the 0-250mA range when the modem is active, for a few milliseconds it can spike to up to nearly 2A when in a region requiring the use of GSM. As such, it's recommended that VMODEM_P be directly connected to a battery or other supply that is capable of such brief spikes. It is also recommended that PCB traces for VMODEM_P and GND be designed to handle such current.

Notecard's logic voltage (VIO_P) is provided by the Notecarrier or host system for digital communication. Either 1.8V or 3.3V may be supplied. Although Notecard typically draws very little current, this supply should be designed with a 150mA budget allocated to the Notecard.

Table 2: Power Interface			
Pin Name	**Direction**	**Pin Numbers**	**Usage**
GND	--	3, 5, 6, 11, 18, 33, 39, 45, 51, 57, 71, 73	0V common ground reference
VIO_P	IN	2, 4	1.8V or 3.3V @ 150mA
VMODEM_P	IN	70, 72, 74	2.5V to 5.5V @ 2A

SERIAL COMMUNICATION

The Notecard API consists of JSON-formatted commands which may be passed over any of several serial interfaces:

- USB Serial Interface
- UART Serial Interface
- I2C Serial Interface communicating using a Blues serial-over-I2C protocol implemented in several Blues Wireless open-source libraries

The USB Serial Interface appears to the host as a USB 2.0 Full Speed CDC device. You can access it from Windows 10 or macOS without a device driver using terminal emulation software. You can access it from an embedded host using open-source Blues Wireless libraries for C, Python, Go, and Arduino.

Table 3: USB Serial Interface			
Pin Name	**Direction**	**Pin Number**	**Usage**
USB_DM	I/O	9	USB D+ data signal
USB_DP	I/O	7	USB D- data signal
VUSB	IN	13	USB +5V from
The USB ground must be tied to Notecard GND			

The UART Serial Interface operates at VIO_P at a fixed baud rate of 9600 using 8-N-1. You can access it from an embedded host using open-source Blues Wireless libraries for C, Python, Go, and Arduino.

Table 4. UART Serial Interface			
Pin Name	**Direction**	**Pin Number**	**Usage**
RX_P	IN	62	Receive data
TX_P	OUT	64	Transmit data

The Notecard acts as an I2C slave device operating at VIO_P, and it implements a simple Serial-over-I2C protocol. You can access it from an embedded host using open-source Blues Wireless libraries for C, Python, Go, and Arduino.

Table 5: I2C Serial Interface			
Pin Name	**Direction**	**Pin Number**	**Usage**
SCL_P	IN	40	I2C clock
SDA_P	I/O	42	I2C data

ATTENTION (ATTN) INTERRUPT

Using software, you can optionally configure Notecard to use the ATTN output pin to:

- Inform the host MCU of certain asynchronous events (such as incoming data availability, or Notecard motion) in an interrupt-driven manner rather than just polling.
- Place the host MCU into a power-off sleep state and wake it back up again.

This pin operates at VIO_P. If it is unused, it can be left disconnected.

Table 6: Attention Interrupt			
Pin Name	**Direction**	**Pin Number**	**Usage**
ATTN_P	OUT	54	Attention pin

AUXILIARY PORTS

An optional Auxiliary UART Serial Interface is available on the AUX_RX_P and AUX_TX_P pins. This interface is inactive unless enabled by raising the AUX_EN_P pin since this UART consumes extra power when in use. It operates at VIO_P at 115200/8-N-1. If this interface is unused, the three pins can be left disconnected.

The AUX1-4 pins operate at VIO_P and can be configured in software to operate in several optional modes such as GPS Tracking Mode, GPIO Mode, and Internet Button Mode. If these pins are unused, they can be left disconnected.

Table 7: Auxiliary Ports			
Pin Name	**Direction**	**Pin Number**	**Usage**
AUX_EN_P	IN	56	Enables 115200 serial port on AUX_RX_P and AUX_TX_P. This port is normally disabled because it consumes up to 100uA of power when enabled.
AUX_RX_P	IN	58	RX data for serial port enabled by AUX_EN_P
AUX_TX_P	OUT	60	TX data for serial port enabled by AUX_EN_P
AUX1	I/O	46	General Purpose IO
AUX2	I/O	48	General Purpose IO
AUX3	I/O	50	General Purpose IO
AUX4	I/O	52	General Purpose IO

EXTERNAL SIM

Notecard contains an integrated SIM but may also be configured to use an external 1.8V (U)SIM via this interface. This interface is powered by the Notecard. Note that use of an external SIM card also requires that the Notecard be re-configured in software with the APN, access technology, and bands appropriate for the SIM's carrier.

Table 8: External SIM Interface			
Pin Name	**Direction**	**Pin Number**	**Usage**
SIM_CLK	OUT	14	Clock
SIM_IO	I/O	12	Data
SIM_NPRESENT	IN	16	Active-low input indicating presence of SIM card, else must be NC. Required if an external SIM is used, and is supported by the mechanical switch in SIM card slot hardware.
SIM_RST	OUT	10	Reset
SIM_VCC	OUT	8	+1.8V supply for external (U)SIM
The external SIM slot ground must be tied to Notecard GND			

ACTIVE GPS

If you choose to connect an Active GPS antenna to the Notecard GPS u.fl connector, you are required to provide your antenna's DC bias voltage to the center conductor of the coax antenna via VACT_GPS_IN. For your convenience and for that purpose only, a +3.8V supply is provided at VACT_GPS_OUT at times when the Notecard's GPS should be enabled.

Table 9: Active GPS Interface			
Pin Name	**Direction**	**Pin Number**	**Usage**
VACT_GPS_IN	IN	22	Active GPS antenna DC bias voltage
VACT_GPS_OUT	OUT	20	+3.8V from Notecard at appropriate times

RESET

Use of this pin is optional. If the host system has a global reset line, this pin should be connected to the host system's reset so that the Notecard resets with the rest of the system. Restrictions on this pin are:

- If this pin is not used it must remain NC.
- The pin is active-low. It must be held low for at least 350nS for a clean reset
- This pin must never be pulled-up. A pull-up would interfere with the Notecard's own internal watchdog timer and thus will prevent reliable operations.
- Notecarriers invert this signal to be active-high. If your system requires an active-high reset, please refer to Notecarrier schematics for a reliable inverter.

Table 10: Reset Interface			
Pin Name	**Direction**	**Pin Number**	**Usage**
NRST	IN	67	Active-low reset

ANTENNAS

Notecard requires an LTE antenna that can support LTE Bands. Outside North America, the antenna should also support GSM bands.

Although all versions of the Notecard require only a single LTE antenna, the "wideband" versions of the Notecard also optionally support a second "Diversity" antenna for maximum range when using LTE Cat-1.

If an application utilizes GPS location, a GPS antenna is also required. Notecard design allows the option of having Notecard inject a bias voltage to power an active antenna's Low-Noise Amplifier, or the designer can inject whatever voltage they require into the antenna's coax by feeding it to the VACT_GPS_IN pin.

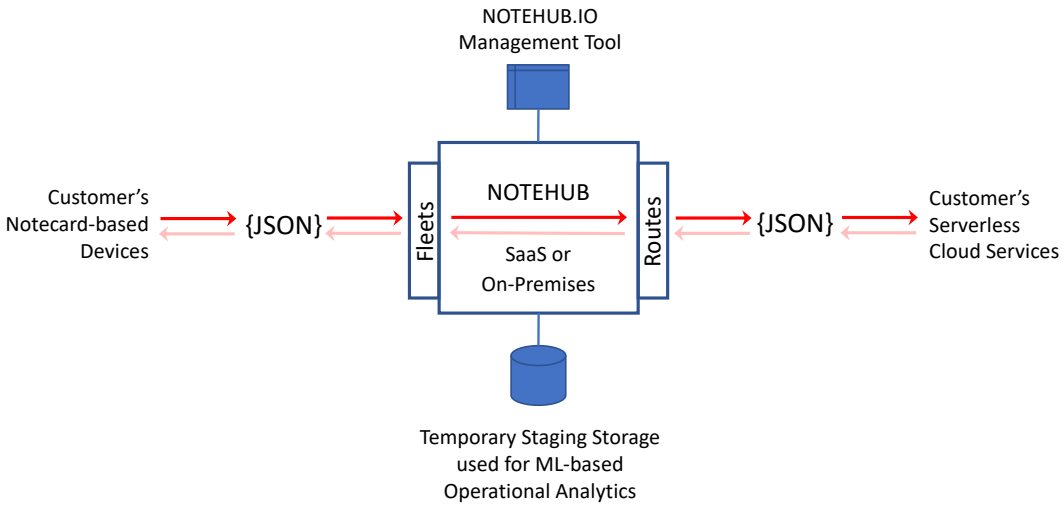
NOTEHUBS

A notehub is a simple cloud-based data router that receives data from notecards, routes data to customers' cloud apps, and accepts HTTPS requests to be sent back to the notecards.

Notecards do not strictly require any service provider's specific implementation of a notehub. Source code for a reference implementation is available as open source on Github.

Blues Wireless hosts a SaaS-delivered version of a Notehub at notehub.io with a free starter tier as well as several paid options based on project team size, data flow rate, data staging period, and the need for large-fleet operational data analytics tools. Through notehub.io, Notecard devices can be upgraded for extended coverage, bandwidth, or lifetime beyond 10 years.

When a device is configured to use a notehub.io instance on AWS or Azure, communication between the carrier and notehub is logically *off the internet,* traveling in a secure tunnel from the cell carrier directly into notehub.io's cloud VPC. In this mode, customer devices are not IP-addressable on the internet, and thus are not subject to internet-based device attack vulnerabilities.



MINIMUM CONFIGURATION

Only two parameters need to be specified in order to get a Notecard to communicate with a Notehub. These parameters are specified by simply sending a JSON command to Notecard:

1) The DNS domain name of the Notehub to be used with this Notecard. By default, the domain is set to NOTEHUB.IO, Blues Wireless's default notehub.
2) A unique name referred to as the "product ID," an identifier instructing the Notehub which project a device belongs to. TLS is used to cryptographically bind this product ID to that project.

MAXIMUM RATINGS

Temperature Range: -35 to 75 Celsius (pending)

TBS

MECHANICAL SPECIFICATIONS

TBS

CERTIFICATIONS

As of February 2019 Notecard A100 gained PTCRB "socket modem" certification as an End-Product", meaning that customers can integrate the card without submitting their own product for further PTCRB certification.

Other certifications TBS

RECOMMENDED OPERATING CONDITIONS

TBS

ORDERING INFORMATION

TBS

REVISION HISTORY

TBS