Saturn

Saturn™

End-to-End Secured Payment Authorization System

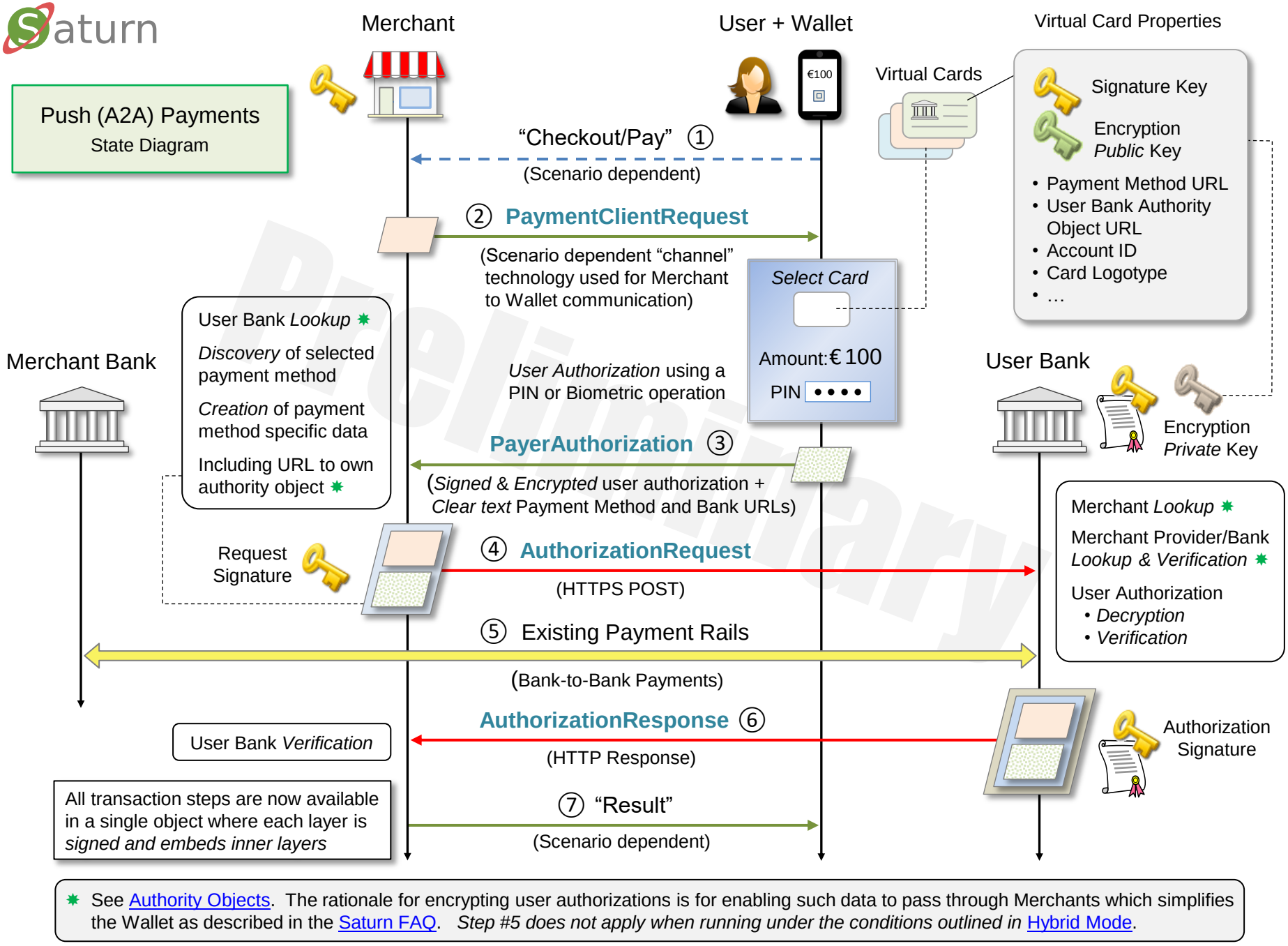
- *Decentralized operation* accomplishes similar goals as 3D Secure and “Tokenization” but *without registries or additional services*
- Facilitates the design of brand/bank independent, “rich UI” wallets, supporting both card- and bank-to-bank payments
- Equally applicable on the mobile Web, locally in a shop, at an automated gas station, or as a “PC companion” on the Web
- *Eliminates* the traditional payment terminal and reduces merchant PCI requirements to a minimum
- Requires a *single* “active” method on the issuer side to function*

** Reservations and reoccurring payments will in non-card-based scenarios need a second method as well*

Disclaimer: This is a system in development and specifications are subject to change without notice

Saturn

Push (A2A) Payments
State Diagram



✸ See Authority Objects. The rationale for encrypting user authorizations is for enabling such data to pass through Merchants which simplifies the Wallet as described in the Saturn FAQ. *Step #5 does not apply when running under the conditions outlined in* Hybrid Mode.

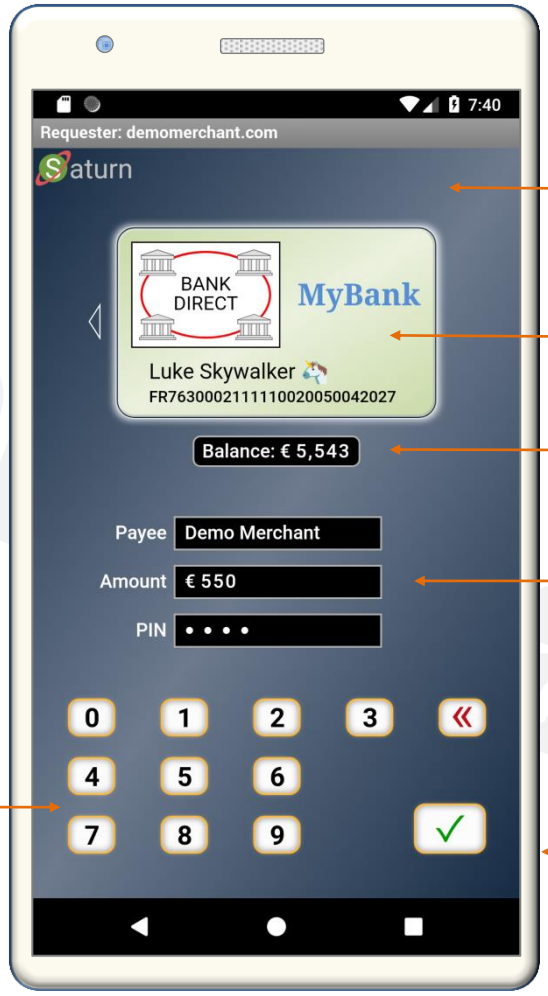
② Merchant Invokes the Wallet with a PaymentClientRequest Message

Payment method URLs to be matched against the virtual cards


```
{
  "@context": "https://webpki.github.io/saturn/v3",
  "@qualifier": "PaymentClientRequest",
  "supportedPaymentMethods": [{
    "paymentMethod": "https://supercard.com",
    "keyHash": {
      "algorithm": "S256",
      "value": "mOkB1PCtDzNiPv07-8EIFah7a4Dwwc9JHT47_1MRJbM"
    }
  },{
    "paymentMethod": "https://bankdirect.net",
    "keyHash": {
      "algorithm": "S256",
      "value": "6HDWDUY9HRGDRb4aW9Vz4G2Uun0Bv1_110VSeAYGdpQ"
    }
  }],
  "paymentRequest": {
    "payee": {
      "commonName": "Demo Merchant",
      "homePage": "https://demomerchant.com"
    },
    "amount": "550.00",
    "currency": "EUR",
    "referenceId": "#1000020",
    "timeStamp": "2020-03-21T06:24:56Z",
    "expires": "2020-03-21T06:55:00Z",
    "software": {
      "name": "WebPKI.org - Payee",
      "version": "1.00"
    }
  }
}
```


The Merchant (Payee) invokes the Wallet (after a user action) with a list of supported payment methods. Those who are matching the user's virtual cards will be shown in the Wallet UI to select from. The **`keyHash`** objects hold JWK "thumbprints" of the public keys associated with the Merchant's authorization signature for a particular payment method / network. The **`paymentRequest`** object contains the actual request data to be reflected in the wallet UI.

② Wallet Receives the PaymentClientRequest



Adapted to:
- *Your* Language
- *Your* Disability

Virtual Card Logo & Account Selector

Optional: Real-Time Account Balance

UI Showing:
- Direct Payment
- Booking
- Gas Station
- Etc.

TEE Protected Keys

PIN or Biometric for User Authorization
(as defined by the *virtual card issuer*, not the Wallet)

When **PaymentClientRequest** has been received by the client, the Wallet user interface is launched. The authorization method may consist of a PIN but could also be a biometric option such as touching a fingerprint reader. The authorization is only used to unlock the Signature Key as described in next slide. Note that the Saturn authorization concept not only emulates payment cards, *but payment terminals as well*.

③ *Internal* Wallet Processing – Creation of *Signed* Authorization Data

```
{
  "requestHash": {                                  <-- Hash of received paymentRequest object
    "algorithm": "S256",
    "value": "DQDUHGcgrlCjONWP8K_pvoqjX5gSQz95mcWDEPeygpg"
  },
  "keyHash": {                                      <-- Copied from PaymentClientRequest
    "algorithm": "S256",
    "value": "6HDWDUY9HRGDRb4aW9Vz4G2Uun0Bv1_110VSeAYGdpQ"
  },
  "domainName": "demomerchant.com",                 <-- Acquired by the Wallet software
  "paymentMethod": "https://bankdirect.net",
  "credentialId": "54674448",
  "accountId": "FR7630002111110020050012733",       <-- Core data of selected virtual card
  "encryptionParameters": {
    "algorithm": "A256GCM",
    "key": "9MdPM5jEnPRtk-yYGIMmYaQLrk0gTXVQNhQQIHQ0aQk"
  },
  "timeStamp": "2020-01-20T11:46:17+01:00",
  "software": {
    "name": "WebPKI.org - Wallet",
    "version": "1.00"
  },
  "authorizationSignature": {                       <-- https://cyberphone.github.io/doc/security/jsf.html
    "algorithm": "ES256",
    "publicKey": {                                  <-- Signature key of selected virtual card
      "kty": "EC",
      "crv": "P-256",
      "x": "censDzcMEkgiePz6DXB7cDuwFemshAFR90UNVQFCg8Q",
      "y": "xq8rze6ewG0-eVcSF72J77gKiD0IHnzpwHaU7t6nVeY"
    },
    "value": "zyKIwU5NtTqoIiBbq0NVP06-v2zXJbsb....ioNTpuaDve-RA5BxiBgfpU_12b6Goixw"
  }
}
```

When the user has authorized the transaction the Signature (private) key associated with the selected card is used to sign a JSON object holding authorization data as follows : **`requestHash`** holds the *hash* of the **`paymentRequest`** object (see PaymentClientRequest slide), while **`accountId`** holds the actual Account ID of the selected card. The **`keyHash`** holds a copy of the data in the initial request associated with the selected payment method. For more information about **`encryptionParameters`**, turn to the slide Risk Based Authentication.

③ Wallet Processing – Creation and Sending of PayerAuthorization Message


```
{
  "@context": "https://webpki.github.io/saturn/v3",
  "@qualifier": "PayerAuthorization",
  "providerAuthorityUrl": "https://payments.mybank.com/authority",
  "paymentMethod": "https://bankdirect.net",
  "encryptedAuthorization": {
    "algorithm": "A256GCM",
    "keyEncryption": {
      "algorithm": "ECDH-ES",
      "publicKey": {
        "kty": "EC",
        "crv": "P-256",
        "x": "TfCrhFwZRU_ea7lUWwRi3HkuyT2yF9IxN5xKh2khjlk",
        "y": "nZFwxLP0TvFXD2xPKzRTIGevgLjpiMw2BP86hszj5x4"
      },
      "ephemeralKey": {
        "kty": "EC",
        "crv": "P-256",
        "x": "80mByDxNt213LAKLjTC7VWLg0HwgZoyrxdf33Cvpk1c",
        "y": "73oDKxbAYxFVbWckvxHY8gO2NY_nK8nCVwWUoP8GBy0"
      }
    },
    "iv": "9AXDHPcmNNn77jK8",
    "tag": "qpUpZZRD0K1JRCyJui_9mw",
    "cipherText": "yUrV2yfBwUoylw2GE-0dsbmT1wbrWhmn....F-7jHwRlVlt6Cvpj0Ok7FD2Kcon_TjiQ"
  }
}
```

"Non-secret" data of selected virtual card

https://cyberphone.github.io/doc/security/jef.html

Encryption key of selected virtual card

Encrypted user authorization

PayerAuthorization messages provide the URL to the issuing bank's "Authority" object and the selected payment method which both are featured in virtual cards. This data is used by Merchants (Payees) for routing payment authorization requests to the applicable Bank. The actual authorization data (see previous slides) is *encrypted* by the Wallet using an *Issuer (not User) specific Encryption key* (with a *matching private key only known by the issuing Bank*), which also is stored in the virtual card. That is, Merchants do not get any information concerning Users (Payers) except their Bank and associated payment method.

Bank/Acquirer ProviderAuthority Object


```
{
  "@context": "https://webpki.github.io/saturn/v3",
  "@qualifier": "ProviderAuthority",
  "httpVersion": "HTTP/1.1",
  "authorityUrl": "https://payments.mybank.com/authority",
  "homePage": "https://mybank.com",
  "serviceUrl": "https://payments.mybank.com/service",
  "supportedPaymentMethods": {
    "https://bankdirect.net": ["https://sepa.payments.org/saturn/v3#account"],
    "https://supercard.com": ["https://sepa.payments.org/saturn/v3#account"]
  },
  "extensions": {
    "https://webpki.github.io/saturn/v3/extensions#hybrid": "https://payments.mybank.com/hybridpay"
  },
  "signatureProfiles": ["https://webpki.github.io/saturn/v3/signatures#ES256.P-256"],
  "encryptionParameters": [{
    "dataEncryptionAlgorithm": "A128CBC-HS256",
    "keyEncryptionAlgorithm": "ECDH-ES",
    "publicKey": {
      "kty": "EC",
      "crv": "P-256",
      "x": "TfCrhFwZRU_ea7lUWwRi3HkuyT2yF9IxN5xKh2khjlk",
      "y": "nZFwxLP0TvFXD2xPKzRTIGevgLjpiMw2BP86hszj5x4"
    }
  }],
  "timeStamp": "2020-03-21T05:32:18Z",
  "expires": "2020-03-21T06:32:19Z",
  "issuerSignature": {
    "algorithm": "ES256",
    "certificatePath": ["MIIBtTCCAVmgAwIB....3FwxFeOawwmz1bM6", "MIIDcjCCAVqgAwIB....e_-5TddhlTUMNPvw"],
    "value": "ZoeXuaOcM_r31oFKdyy0o7Ad5bl1WUC-....QqCS23ihlzQBy-5l7RyEO_HuZiuWmZRw"
  }
}
```


Authority object URL of a virtual payment card issued by this bank

Accepted signature types

https://cyberphone.github.io/doc/security/jef.html

https://cyberphone.github.io/doc/security/jsf.html

"Authority" objects hold Keys, Payment methods, and URLs which are used by Merchants, Banks, and Acquirers as *Secure Distributed Entity Databases* creating the foundation for scalability including *Delegated Trust*. "Authority" objects are *published on the Internet* and accessed by HTTP GET operations. A Bank/Acquirer "Authority" object is signed by the Bank/Acquirer itself. The **`paymentMethods`** object declares the payment methods understood by the Bank. The **`encryptionParameters`** are used by Issuers for encrypting user account data.

Merchant (Payee) PayeeAuthority Object


```
{
  "@context": "https://webpki.github.io/saturn/v3",
  "@qualifier": "PayeeAuthority",
  "authorityUrl": "https://payments.bigbank.com/payees/86344",
  "providerAuthorityUrl": "https://payments.bigbank.com/authority",
  "localPayeeId": "86344",
  "commonName": "Demo Merchant",
  "homePage": "https://demomerchant.com",
  "accountVerifier": {
    "algorithm": "S256",
    "hashedPayeeAccounts": ["kUwpqk-cbkDaBjwDD_etPSh_FtC-Ap2K_A2MQzXNy_U"]
  },
  "signatureParameters": [{
    "algorithm": "ES256",
    "publicKey": {
      "kty": "EC",
      "crv": "P-256",
      "x": "_7bQ8JTt6_r1lh46kwmwypqMkZOJ0cYs-w2LHWOYt5M",
      "y": "tLcyLWDQoAk4cMaWY7BdV3JaywQQoLxO2WQ30Klj6fc"
    }
  }],
  "timeStamp": "2020-03-21T05:32:30Z",
  "expires": "2020-03-21T06:32:31Z",
  "issuerSignature": {
    "algorithm": "ES256",
    "publicKey": {
      "kty": "EC",
      "crv": "P-256",
      "x": "-Vr8Wk3ygt5J2_J3R8TrRaa-AWW7ZiXa6q1P7ELs6gc",
      "y": "Vuc6z3WiZ3tgXTXvU6F5qdiiYePWeUI1q9Tx83ySDcM"
    },
    "value": "Xb_yLOpGbmboDjufFnCDdRfyAJiNm1-U....8ou__kr_izI05kOnJshpd-JkpcWcP4kw"
  }
}
```


URL to the Merchant "Authority" object

URL to the Merchant Bank/Acquirer "Authority" object

Merchant core data

Merchant signature key

https://cyberphone.github.io/doc/security/jsf.html

The same public key as in the Bank/Acquirer "Authority" object signature certificate

A Merchant (Payee) "Authority" object is like a *short-lived*, *automatically updated*, *X.509 certificate not requiring a CA*. Such an object is published on the address **`authorityUrl`** hosted by the party (Bank or Acquirer) which vouches for the Merchant. If a Merchant is to be "revoked", the object is simply removed. To automate revocation checks, there is an **`expires`** attribute which also is used to clear caching of Merchant "Authority" objects. The **`signatureParameters`** list enable key renewals as well as validation of signatures using old keys.

④ Merchant Creates and Sends an AuthorizationRequest Message

```
{
   "@context": "https://webpki.github.io/saturn/v3",
   "@qualifier": "AuthorizationRequest",
   "recepientUrl": "https://payments.mybank.com/service",
   "authorityUrl": "https://payments.bigbank.com/payees/86344",
   "paymentMethod": "https://bankdirect.net",
   "paymentRequest": {

      Copy of the original paymentRequest
   },
   "encryptedAuthorization": {

      Copy of the original encryptedAuthorization
   },
   "payeeReceiveAccount": {

   },
   "referenceId": "#1000006",
   "clientIpAddress": "220.13.198.144",
   "timeStamp": "2020-03-21T06:25:06Z",
   "software": {
      "name": "WebPKI.org - Payee",
      "version": "1.00"
   },
   "requestSignature": {
      "algorithm": "ES256",
      "publicKey": {
         "kty": "EC",
         "crv": "P-256",
         "x": "_7bQ8JTt6_r1lh46kwmwypqMkZOJ0cYs-w2LHWOYt5M",
         "y": "tLcyLWDQoAk4cMaWY7BdV3JaywQQoLxO2WQ30Klj6fc"
      },
      "value": "91wNxmoZt-TKUGD1R7prluueL2DSv9iZ....TqYipTRDXSewSlfWgnoxsTkjkw07pJog"
   }
}
```

Where the message is actually sent

URL to Merchant "Authority" object

Payment method (must match user authorization)

Sample data for a SEPA payment method:

```
"@context": "https://sepa.payments.org/saturn/v3#account",
"iban": "FR7630004003200001019471656",
"nonce": "nZFwxLP0TvFXD2xPKzRTIGevgLjpiMw2BP86hszj5x4"
```

https://cyberphone.github.io/doc/security/jsf.html

Merchant signature key

The **AuthorizationRequest** is sent by a Merchant (Payee) to the **`serviceUrl`** of the "Authority" object given by the user's choice of payment card (method). See providerAuthorityUrl. The inclusion of **`authorityUrl`** enables the targeted User Bank to verify that the Merchant belongs to a known Bank-to-Bank or Acquirer payment network.

⑤ User Bank Responds with an AuthorizationResponse Message

```
{
   "@context": "https://webpki.github.io/saturn/v3",
   "@qualifier": "AuthorizationResponse",
   "accountReference": "FR*0124",
   "encryptedAccountData": {
      Parameters removed for brevity…

      "cipherText": "okjRig8y97oHa0kw7buu17XcTZOZAtS1....XG4BoMqDwY0e2fxlGPSHzko5Hs_0UHXz"
   },
   "referenceId": "#0100345296",
   "logData": "CT100002",
   "timeStamp": "2020-03-21T06:25:06Z",
   "software": {
      "name": "WebPKI.org - Bank",
      "version": "1.00"
   },
   "authorizationRequest": {
      Copy of the original AuthorizationRequest
   },
   "authorizationSignature": {
      "algorithm": "ES256",
      "certificatePath": ["MIIBtTCCAVmgAwIB....3FwxFeOawwmz1bM6", "MIIDcjCCAVqgAwIB....e_-5TddhlTUMNPvw"],
      "value": "b03W5RPCmoA2ARILtbdvCrlrAj5i0Cr4....hib3XUqun9KxpbL6Ig7i4pA_ko7Gf4yA"
   }
}
```

Optional short form of the user account to be featured in receipts etc.

Encrypted user account data

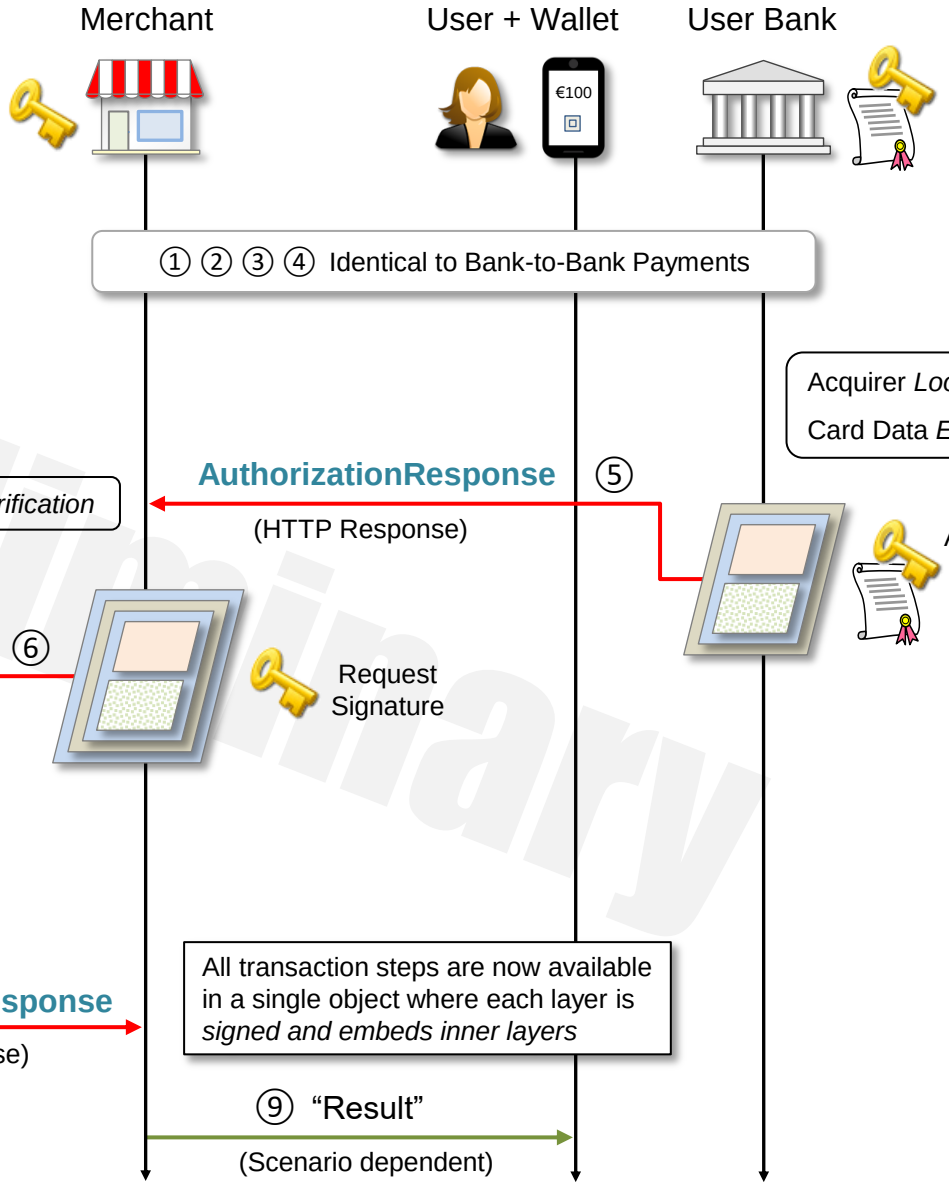
https://cyberphone.github.io/doc/security/jsf.html

User Bank certificate path

After received the **AuthorizationRequest**, User Bank performs an extensive list of operations to verify the validity of the request, including fetching the Merchant's (Payee) PayeeAuthority and ProviderAuthority objects. If the verification succeeds, User Bank responds with an **AuthorizationResponse** message which in addition to the original **AuthorizationRequest**, also holds the user's account ID encrypted by the Merchant provider's encryption key. This information is used for Card Payments and Refunds.

Saturn

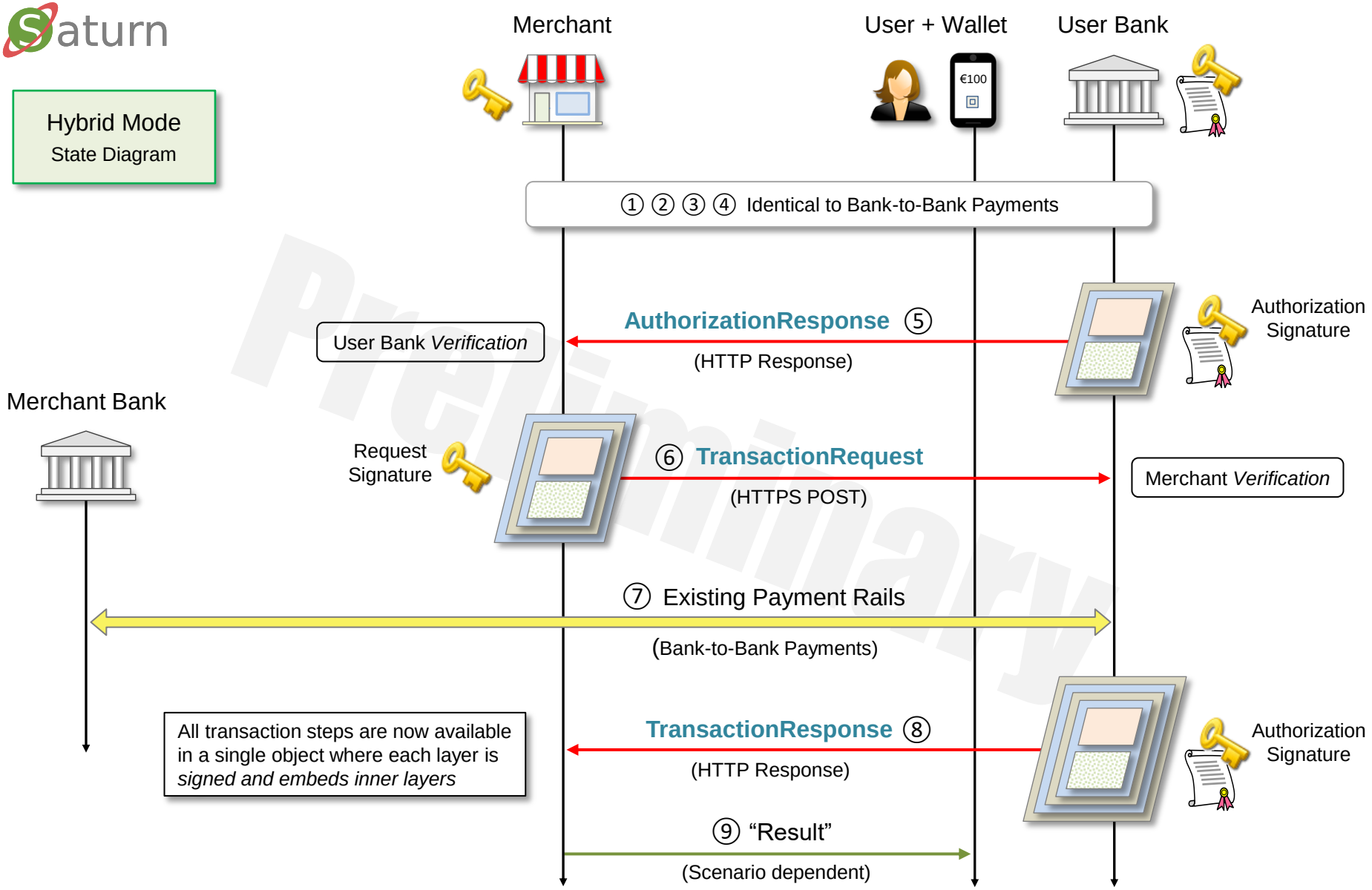
Card Payments
State Diagram



✸ See Authority Objects. The flow may stop after step #5 resulting in a *Secure Authorization Object* which *only* can be activated by another *Request*. This scheme supports hotel bookings, upfront reservations for automated gas stations, as well as reoccurring payments. The card data *Encryption* and *Decryption* processes enable standard card data to securely pass through Merchants from Issuers to Acquirers.

Saturn

Hybrid Mode
State Diagram



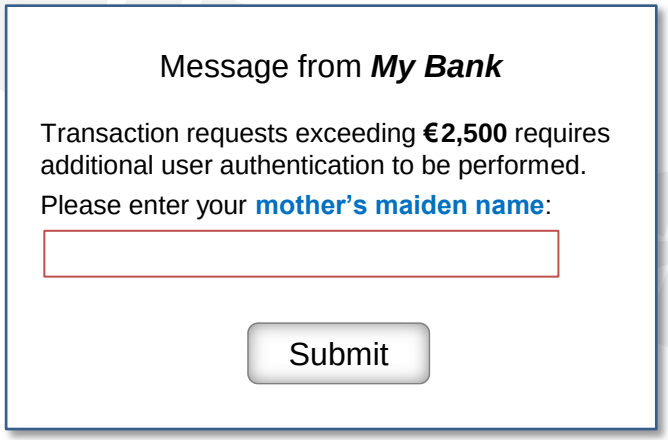
In the Hybrid mode traditional card payment methods are "emulated" including support for hotel bookings, upfront reservations for automated gas stations, as well as reoccurring payments. For three-corner payment schemes like PayPal and Alipay as well as for payments where the User and Merchant have the same bank, *step #7 is not applicable*.

Private Messaging and Risk Based Authentication

```
{
  "@context": "https://webpki.github.io/saturn/v3",
  "@qualifier": "ProviderUserResponse",
  "encryptedMessage": {
    "algorithm": "A256GCM",
    "iv": "_K4Sgt5y1uKhwiSi",
    "tag": "Xmqyx5XZWmxSFfypag-y_A",
    "cipherText": "qXIsLsZ-zIxVllV920dpxPmTOwGRghU_....fsxbw1LX61Tu6GbsSw1gXEcwkW8S4fOQ"
  }
}
```

https://cyberphone.github.io/doc/security/jef.html

When decrypted and rendered by the Wallet (sample)



Occasionally a User Bank needs to inform the user of something related to an AuthorizationRequest like an account overdraft. Another situation requiring an action from the user's side is when the amount requested is unusually high or when "suspicious" user patterns have been identified. In both cases the request is *ignored* and the normal response is replaced by a message which only the (Wallet) user can read while still being delivered through the Merchant's "channel" to the Wallet. Privacy is accomplished by the User Bank encrypting the message contents with the symmetric key supplied in **`encryptionParameters`**
(see Creation of Signed Authorization Data). This key is a random value generated for each Wallet invocation.

A private message like above (requiring an *action*), forces the Wallet adding the response to the user authorization data and then performing a full signed and encrypted User Authorization request again. This process may be repeated if necessary.

RefundRequest Option


```
{
   "@context": "https://webpki.github.io/saturn/v3",
   "@qualifier": "RefundRequest",
   "recepientUrl": "https://payments.bigbank.com/refund",
   "amount": "550.00",
   "payeeSourceAccount": {
      "@context": "https://sepa.payments.org/saturn/v3#account",
      "iban": "FR7630004003200001019471656"
   },
   "referenceId": "#1000004",
   "timeStamp": "2020-03-21T07:07:50Z",
   "software": {
      "name": "WebPKI.org - Payee",
      "version": "1.00"
   },
   "authorizationResponse": {

      Copy of the original AuthorizationResponse

   },
   "requestSignature": {
      "algorithm": "ES256",
      "publicKey": {
         "kty": "EC",
         "crv": "P-256",
         "x": "_7bQ8JTt6_r1lh46kwmwypqMkZOJ0cYs-w2LHWOYt5M",
         "y": "tLcyLWDQoAk4cMaWY7BdV3JaywQQoLxO2WQ30Klj6fc"
      },
      "value": "rrqbEkm7ZM6uGjnIWg-3c2YHPXsDhzVz....FsMSNotc7QvAsvn2sTFJ-GGdN5Fx6EfQ"
   }
}
```

https://cyberphone.github.io/doc/security/jsf.html

Merchant signature key

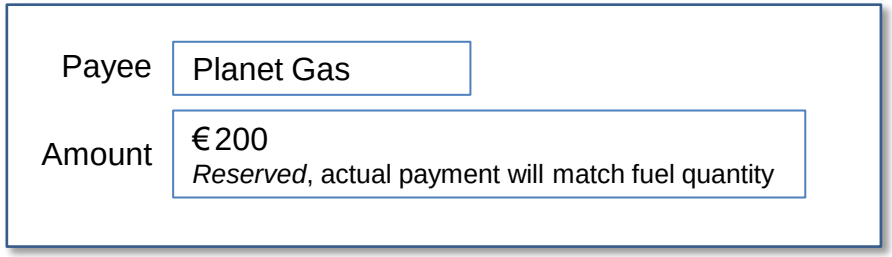
By including the account ID of the user (but *encrypted* with the Merchant's *payment provider key*), in the AuthorizationResponse object the Merchant can (*aided by their payment provider*), transfer money in the opposite direction. A **RefundRequest** message consists of an embedded **AuthorizationResponse** and an *amount*, signed by the Merchant. Note that the Merchant must send the refund request to *its own bank*. The Merchant's Bank is supposed to respond with (a here not shown) **RefundResponse** object.

Gas Station Option (Reserve/Capture)

```
{
  "@context": "https://webpki.github.io/saturn/v3",
  "@qualifier": "PaymentClientRequest",
  "supportedPaymentMethods": [
    Parameters removed for brevity…
  ],
  "paymentRequest": {
    "payee": {
      "commonName": "Planet Gas",
      "homePage": "https://planetgas.com"
    },
    "amount": "200.00",
    "currency": "EUR",
    "nonDirectPayment": "GAS_STATION",
    "referenceId": "#1000017",
    "timeStamp": "2020-03-21T06:22:59Z",
    "expires": "2020-03-21T06:53:00Z",
    "software": {
      "name": "WebPKI.org - Payee",
      "version": "1.00"
    }
  }
}
```

New element

User Interface Implications (Non-normative)



Gas Station payments presume Card Payments or Hybrid Mode to be carried out.

Saturn - FAQ

Q: Doesn't Saturn's Merchant-to-User Bank AuthorizationRequest introduce security risks?
A: Yes, similar risks as on-line bank applications which effectively are open to requests from *anywhere*. Security features include:
- Small and strict message format
- All messages are signed using industry standard cryptographic algorithms
- AuthorizationRequest is signed by the Merchant and vouched for by the Merchant's Bank/Acquirer through the PayeeAuthority object which also enables verifiable Merchant account data
- User signs a hash of **`paymentRequest`** with a key *which only the User Bank knows about*
- Integral support for RBA (Risk Based Authentication)
- Tokenization of payment authorizations makes attacks on Merchant databases useless

Q: Can you trust the Wallet key storage?
A: Saturn depends on hardware backed keys like the AndroidKeystore.

Q: Doesn't Saturn effectively requires new client-side technology to fly?
A: Yes indeed, exactly like Apple Pay did. W3C's PaymentRequest is instrumental.

Q: Wouldn't it be better sending requests from the Wallet directly to the User Bank and then handing over responses to the Merchant?
A: Not really, see https://cyberphone.github.io/doc/defensive-publications/payment-authorization-scheme.pdf for more details on this matter which also is a *prerequisite for Wallet payment method independence*.

Q: Is Saturn a "Push" or "Pull" payment system?
A: *Saturn is not a payment system*, it is rather a scheme where a User *authorizes* Merchant-initiated *requests** which are transported back to the User Bank via the Merchant. That is, the actual payment system is not a part of the depicted scheme.

Q: How does Saturn relate to ISO 20022, ISO 8583, and SEPA?
A: Only the actual payment systems need payment-system specific security, format, names, conventions, and processing. The ability including payment-system specific data in AuthorizationRequest makes Saturn compatible with just about any payment system.

Q: How are Virtual Cards enrolled?
A: Virtual Cards would typically be enrolled from the User Bank's Web site using a secure enrollment protocol like: https://cyberphone.github.io/doc/security/keygen2.html

Q: Is Saturn a REST API?
A: No, because a payment is not a resource but rather an event with transactional behavior. In addition, messages are uniquely defined by their JSON contents making *digitally signing*, *embedding*, *debugging*, and *documenting* straightforward. Wallet communication is based on an *interactive*, *scenario-dependent*, *asynchronous*, *bi-directional* message channel. See: https://cyberphone.github.io/doc/web/yasmin.html

* Enabling Saturn supporting not only direct payments, but bookings, reoccurring payments, and automated gas station payments without modifications to the underlying payment system