BIS Innovation Hub

Bank of England

Project Keystone

Unlocking data analytics for ISO 20022 payments

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Acronyms

CPMI	Committee on Payments and Market Infrastructures
ISO	International Standards Organisation
RTGS	Real-time gross settlement
PSO	Payment system operator
G20	Group of 20
IPS	Instant payment system
BIC	Bank identifier code
LEI	Legal entity identifier

Executive summary

Project Keystone, an initiative by the BIS Innovation Hub London Centre in collaboration with the Bank of England, has developed an analytical prototype for ISO 20022 payment messages.

This project addresses the needs of current and future adopters of ISO 20022 by facilitating advanced analytical capabilities. Keystone enhances the harmonised use of ISO 20022 standards, allowing for consistent analysis of payment data across jurisdictions.

The prototype achieves this through two key components: a data transformation and storage platform for ISO 20022 payment messages, and analytics modules for economic, financial and compliance analysis.

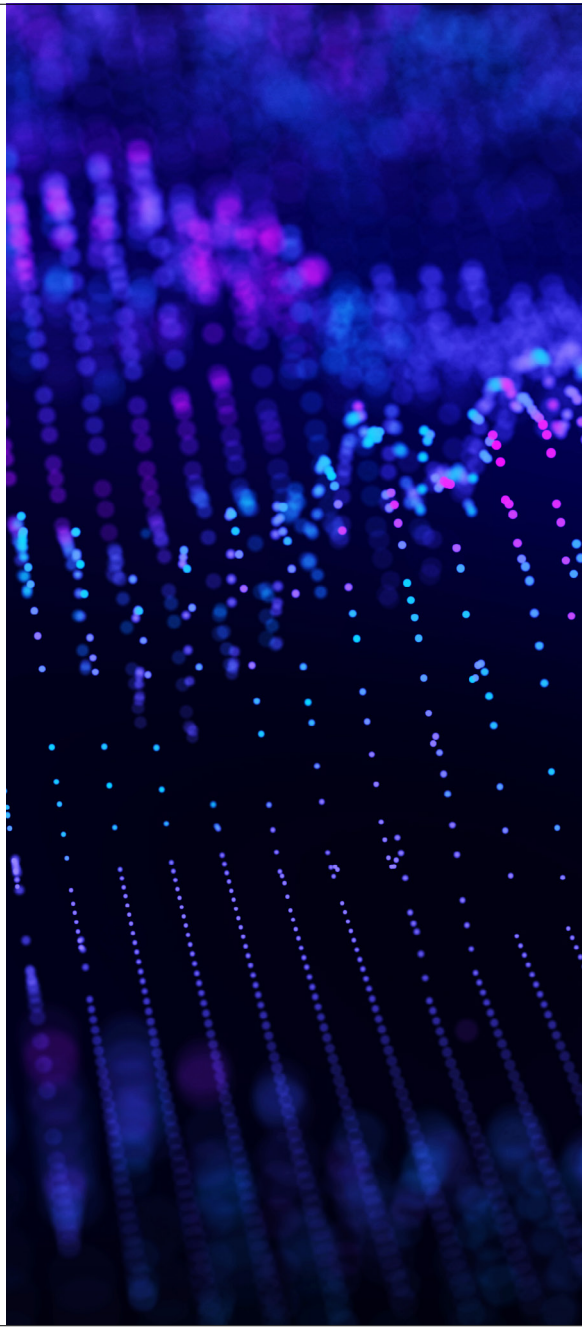
Project Keystone demonstrates the significant benefits of ISO 20022 for analytical purposes. The prototype enables ad hoc analysis by payment system operators (PSOs) using pre-defined analytical modules designed to answer key questions surrounding payment systems operations. This approach aims to unlock future use cases by providing a well structured foundation upon which they may be easily built.

Keystone is designed to work with wholesale payment system data, as the payments within it are typically between financial institutions and corporates. This enables beneficial insights into topics such as liquidity and economic forecasting. By design, Keystone restricts the access of any potential personal data included in payment messages, allowing its users to view the results of validation checks, but not the underlying data.

The Keystone prototype includes components that can be utilised in jurisdictions with varying levels of ISO 20022 adoption.

While these analytics components are effective even with minimal implementation of ISO 20022, the prototype showcases the full potential of more comprehensive ISO 20022 implementations.

As central banks and payment system operators continue to transition to ISO 20022, Project Keystone serves to engage the central banking community with a prototype to show how the analysis of ISO 20022 might be conducted, and the value that can be gained.



Project introduction

The expanding use of ISO 20022 standards for payment messages in real-time gross settlement (RTGS) systems means that many central banks will be migrating to this standard in the coming years.

Seventy-eight per cent of payment system operators (PSOs) have either implemented ISO 20022 or have concrete plans to implement it in their systems (CPMI (2024)).

Project Keystone has developed an analytics toolkit for ISO 20022 payment messages. Harmonising the use of ISO 20022 data is a key deliverable under the G20 cross-border payments programme (FSB (2023)). Keystone shows the potential benefits of these harmonisation efforts, by creating tools for similar analysis of payment data to be performed across jurisdictions.

ISO 20022 provides several improvements over prior standards. First, it requires more structure to the data contained within a payment message.

For example, where prior standards may have allowed for a corporate postal address to be a single data element, ISO 20022 enables the individual components of an address, such as town, postal code and street name, to be separate data elements. This enhanced granularity can reduce ambiguity in payment processing systems, such as compliance screening tools, potentially leading to an increase in automated payment processing. The second area of improvement is related to the inclusion of additional data elements within the payment message.

While the enhancements to the data structure provide benefits, they also can lead to additional complexity in parsing and analysing these data. Keystone can assist central banks and PSOs in this respect, easing the work needed to access and analyse this key information.

Keystone has sought to develop a prototype ISO 20022 analytics platform. It is intended to enable the central banking community to engage with the prototype, learning from the implementation and design of Keystone, and potentially using it to accelerate their own development efforts.

As much of the focus to date around ISO 20022 has been focused on the implementation of the standard into payment systems, Keystone serves to build on these efforts by allowing PSOs to more easily realise the benefits of the ISO 20022 standard. Additionally, as international harmonisation of the use of ISO 20022 will lead to improvements in cross-border payments (CPMI (2023)), Keystone could enable PSOs to more easily align with the international implementation of the standard.

To achieve these goals, Project Keystone sought to achieve two key objectives:

- Create an ISO 20022 data parsing and storage platform.
- Create analysis modules in the areas of liquidity management and liquidity risk, economic monitoring, alignment with the Bank for International Settlements (BIS) Committee on Payments and Market Infrastructures (CPMI) ISO harmonisation requirements (CPMI (2023)), and fraudulent payments.

78%

of payment system operators have either implemented ISO 20022 or have concrete plans to implement ISO 20022 in their systems (CPMI Oct 2023).

Why are ISO 20022 data important?

The widespread global adoption of ISO 20022 enables PSOs to utilise a more universally interoperable messaging standard.

The standard provides a common dictionary for cross-border payments and provides more structured data compared with prior standards. This additional structure can enhance the transaction screening process for sanctions, anti-money laundering and fraud (CPMI (2023)).

In addition to providing a standardised and structured data format, the ISO 20022 standard includes new data elements. Of note, the 'purpose of payment' field, which enables payments to be tagged with a categorised reason for that payment, has strong potential benefits.

A recent consultation put forward by the Bank of England highlighted the following areas of benefit for purpose codes:

- prioritising payments
- financial crime risk and fraud prevention
- new and innovative payment services and improving credit decisions
- efficient reconciliation
- exception processing
- market intelligence
- identifying vulnerable consumers
- providing more information to payees and payers about the payments they make and receive.

(Bank of England)

> Having many systems speaking the same language drives towards one of our key goals of wider interoperability across the payment chain, not just within the UK but worldwide too, and is an important tenet of the G20 cross-border payments roadmap.
>
> **Cleland**

Project components

Data pipelines

- Keystone's core data analysis runs through a single data pipeline. The pipeline ingests ISO 20022 messages from the payment system into a parsed format ready for storage in a relational database.
- Keystone supports an application programming interface (API) for ingesting and processing ISO messages, and a batched processor for bulk ISO processing via file upload.
- The project uses configuration files to inform the software on how to parse and analyse the ISO 20022 data. This enables future scalability to other message types without the need to modify the underlying code base.
- This prototype focused on the payments clearing and settlement (PACS) family of messages due to their ability to move funds between institutions. In scope were PACS.004, PACS.008 and PACS.009 messages.

Each of these message types represent a specific type of payment:

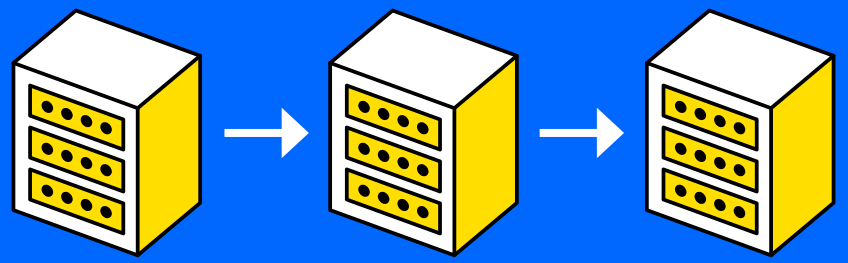
- PACS.008 messages are used to move funds from a debtor account to a creditor account.
- PACS.009 messages are also used for the movement of funds between accounts but require that all parties within the payment be financial institutions.
- PACS.004 messages are used to return a previously sent payment.

- Keystone follows a medallion architecture model, which enables data systems to respond to changing requirements and allows for the greatest possible flexibility for future enhancements.

Diagram: Medallion Architecture

A medallion data architecture refers to the sequential processing and refinement of data through a pipeline.

It is comprised of three medallions: bronze, which contains unprocessed data; silver, containing parsed data; and gold, which contains the aggregated information used for data visualisations.

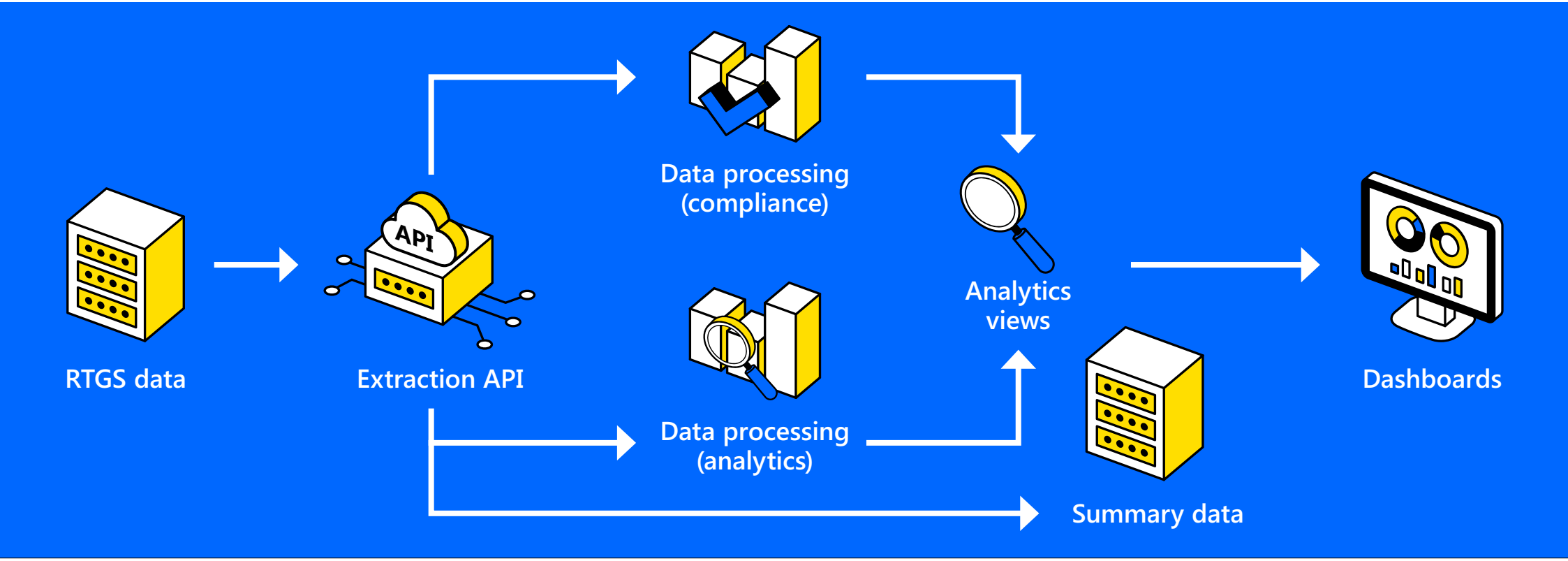


Upon receiving an ISO 20022 message, Keystone will:

- Store the message, and any associated metadata about the transaction, into the 'bronze' data store. The bronze layer stores the message in its raw format, ensuring that no information can be lost from the system.
- The message will then be processed into the "silver" data store. This process involves parsing the message into its component parts using the configuration files discussed previously. At this stage, the message is ready for analysis and can be queried by data analysts.

1. The silver layer contains the results of the message analysis needed to support the analysis layers discussed later in this report.
2. Additionally, the silver layer contains a summarisation table, where each message processed is normalised and made available for data analysis.

- Finally, the message is processed into the "gold" data store. The gold layer holds summarised information about the message. This summary enables dashboards, and common queries to be conducted without the need for exhaustive queries of the bronze or silver layers.



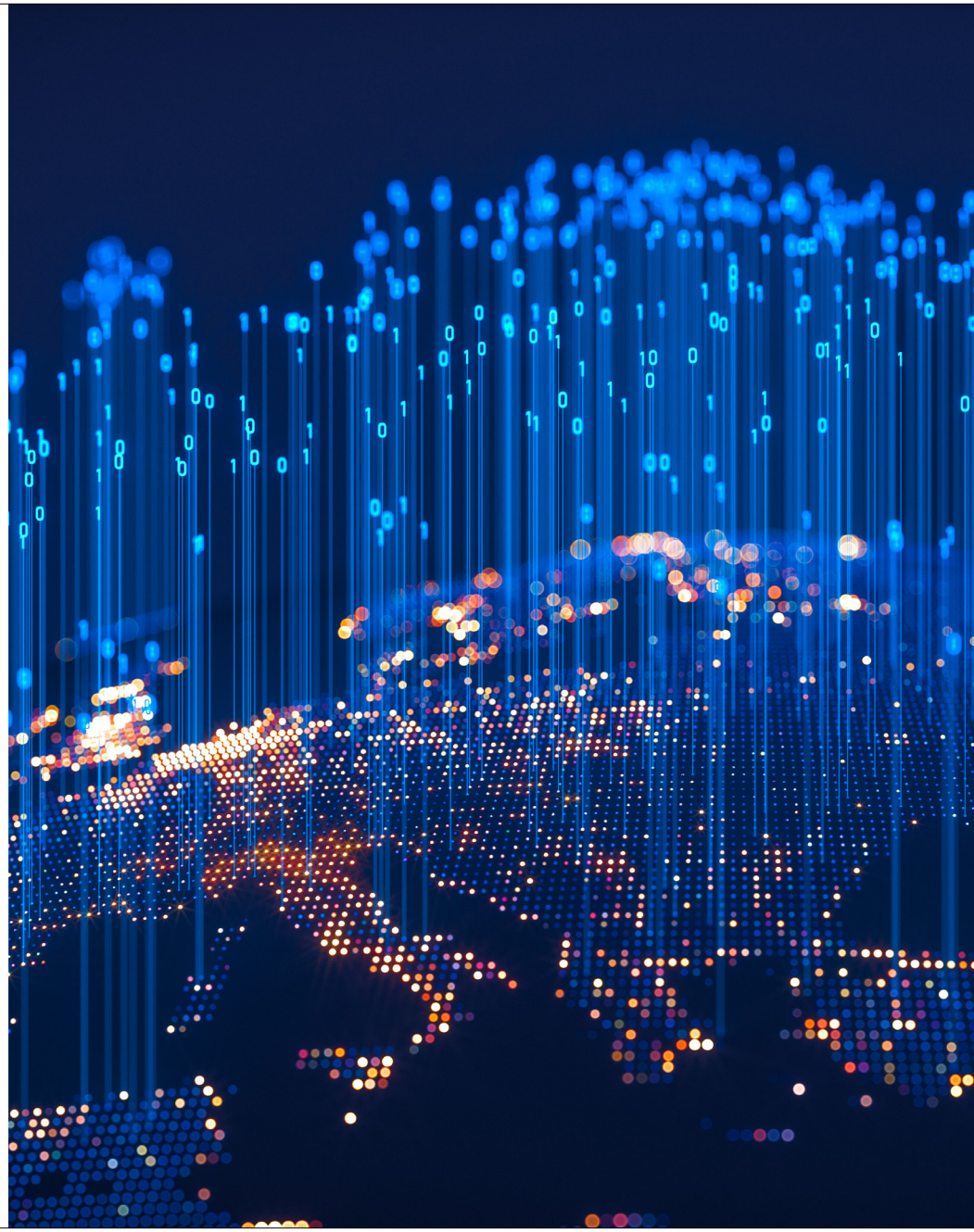
Technical considerations

To meet the project goals, Keystone prioritised the flexibility of deployment from both a technical implementation and a usage perspective. To enable flexible implementation, Keystone was developed with fully open source components, enabling users to freely use the developed prototype.

Special focus was given to ensuring that the complexity of the technical components was minimised, enabling deployment in both on-premises and cloud environments. This was balanced with the need to process large volumes of data, enabling Keystone to process over a million transactions per day, handling the current volumes of RTGS systems. The prototype leverages Kubernetes pods[1] for deployment, enabling scalability to higher volumes as needed.

Keystone provides high levels of configurability. Regardless of the implementation of the ISO 20022 standard (which can vary slightly from jurisdiction to jurisdiction), the system can be configured to handle the messages. This feature ensures the future resilience of the system, allowing for updates to the ISO 20022 standard to be incorporated into the system.

1. Kubernetes pods are the smallest deployable units in Kubernetes (an open source system for automating deployment, scaling and management of containerised applications), consisting of one or more containers that share the same network and storage resources. In this context, they are used to deploy and manage containerised applications, ensuring efficient scaling and orchestration. By leveraging Kubernetes pods, the system can dynamically adjust to handle increased transaction volumes by adding more pods as needed.



Data analysis

Messaging alignment

- While an internationally recognised standard, ISO 20022 has been implemented in different ways globally. In recognition of the disparate implementations of the standards that have emerged, the CPMI has proposed a set of requirements (CPMI (2023)) for the use of ISO 20022 in cross-border payments.
- To assist in the implementation of homogeneous standards, Keystone has developed checks across several of the CPMI recommendations.

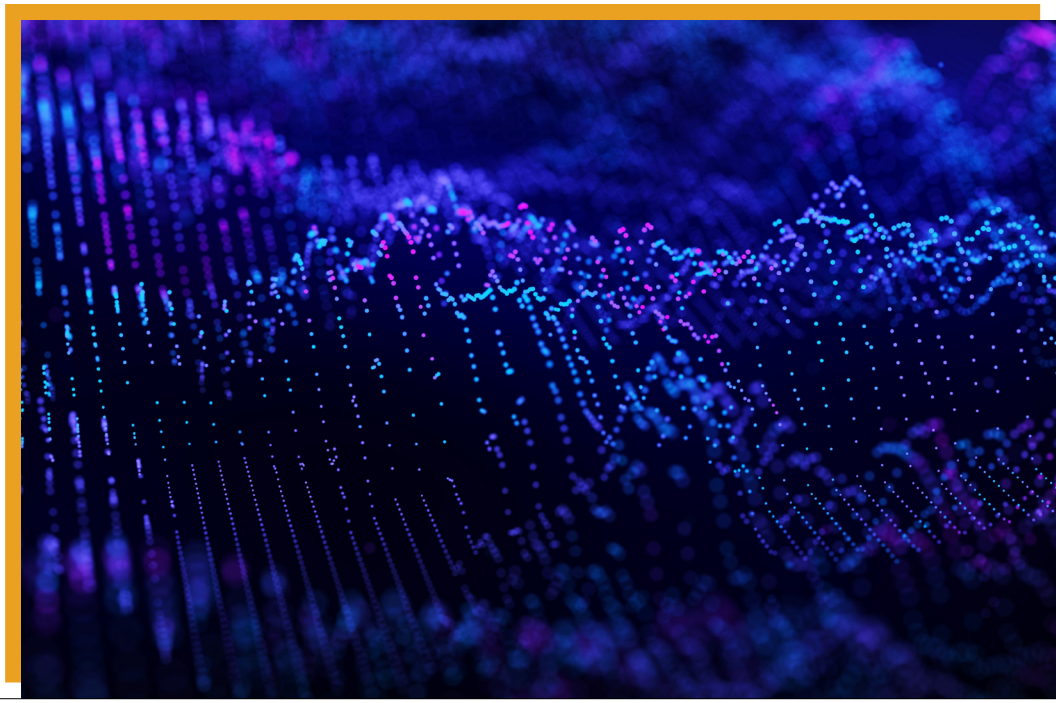
- The project enables analysis of the use of "required" and "recommended" fields according to the CPMI data model. Messages receive a score for the percentage of required fields present in the message, as well as for the recommended fields. The system also logs which data elements are missing from the message, enabling PSOs to ascertain which data elements are consistently missing from messages within their system.
- As the analysis of the use of required and recommended fields is derived from a configuration file, Keystone also supports individual PSOs with their ability to set up their own requirements configurations. This flexibility enables PSOs to run bespoke analysis on data running through their systems.

- Keystone further enables the analysis of the data within the ISO message elements. The first three checks are related to data integrity:
  1. The system enables the validation of data elements referencing an external code set list.[2] Within the prototype, the system enabled the validation of the purpose of payment codes.
  2. It enables a check to ensure that dates and times are formatted with a consistent time zone (Universal Time Coordinated (UTC) or UTC offset).
  3. It checks for the usage of structured account identifiers, such as IBANs or unique account numbers, rather than the use of an individual's name or address.
- The second set of checks relates to the structure of the data within ISO message elements:
  1. Keystone checks for the structured identification of financial institutions via the reference to either a Bank Identifier Code (BIC) or Legal Entity Identifier (LEI).
  2. Keystone checks for the structured identification of all entities involved in a transaction via a reference to a BIC or an LEI.

It is important to note that as Keystone is intended to be used in RTGS systems, individuals' personal data are strictly limited due to the nature of messages within that system. Transactions within the RTGS system are typically between financial institutions and corporates and not of a personal nature.

By design, Keystone restricts access to any personal data included in payment messages, allowing users to view the results of the validation checks but not the underlying data.

The checks in messaging compliance support PSOs in validating that messages within their payment system follow international standards. Compliance with these standards contributes to the delivery of an enhanced cross-border payment experience for all users.



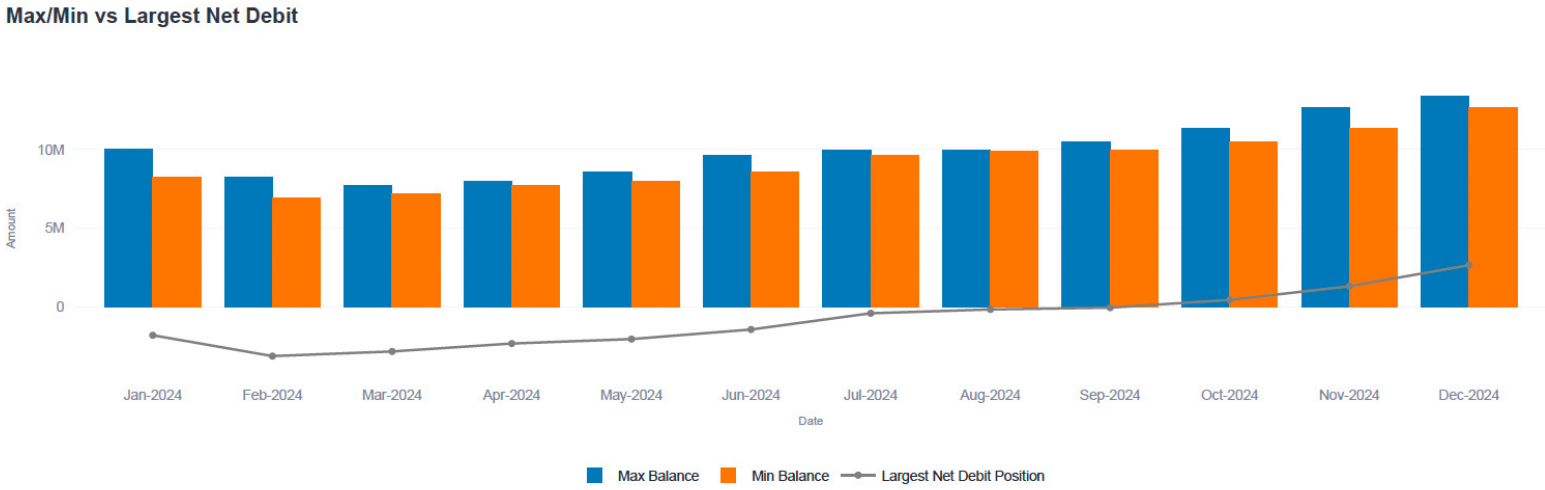
2. External codes are predefined four-letter codes with a nationally or internationally defined meaning.

Liquidity monitoring

- The liquidity monitoring module focuses on enabling PSOs to more effectively analyse the shifts in liquidity within their system due to transactions. A strong understanding of liquidity dynamics allows operators to identify potential bottlenecks and anticipate periods of stress. By tracking intraday liquidity positions and flows, the module supports proactive decision-making and enhances transparency.
- Three components were created for this analysis:
  - The first enables the analysis of liquidity inflows and outflows, along with the maximum intraday net debit position obtained by an institution. This enables PSOs to view the demands upon liquidity by institutions, enabling supervisors to ensure that banks have adequate liquidity to meet demands in times of stress.
  - The second allows PSOs to assess the timing of payments made within the system against historical norms, as the delay in timing of payments can be an early indication of liquidity stress within the system (Bech et al (2012)).
  - Finally, Keystone enables a network view of liquidity movement within the system. This allows PSOs to view the most active participants by volume, as well as which participants are most closely interlinked.

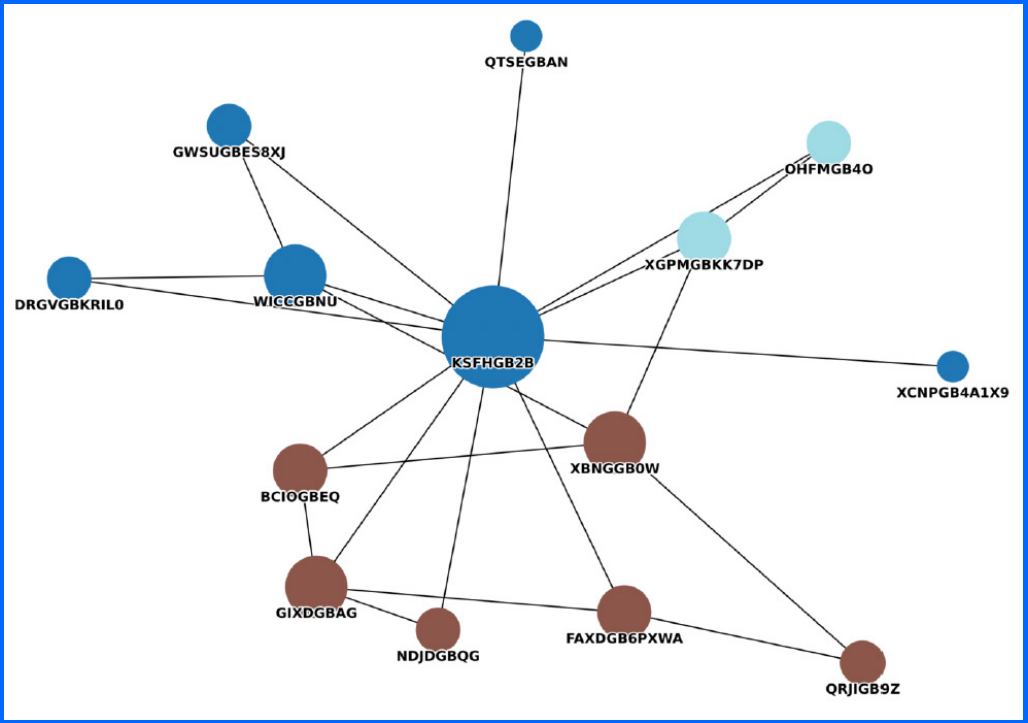
This network view additionally allows PSOs to view their system as an interconnected graph, allowing historical analysis of the degrees of completeness of the network and reciprocity within the network.

Liquidity management dashboard



1. **Network graphs:** a network is comprised of nodes and edges, where a node is a participant in the payment network and an edge represents a relationship between the nodes. In this case, an edge represents payments made from one participant to another.
2. **Degrees of completeness:** for any network, it is possible to measure the degree of completeness. Completeness is simply the number of links within the network relative to the number of possible links. A network with a completeness of zero would arise if no payments were made between the participants, while a completeness of one would require each participant to interact with every other participant in the network. Highly complete networks are more resilient to operational shocks affecting one of the participants, as payments may bypass an institution suffering from an outage (Becher et al (2008)).
3. **Reciprocity:** network reciprocity is the fraction of network edges that are bidirectional (eg payments from participant A to participant B also have payments from participant B to participant A (Bech and Atalay (2008)). More reciprocal networks can lead to improved network stability, efficiency and reliability.

Payment network graph



Economic monitoring

ISO 20022's use of a defined code set for the purpose of payment offers the promise of near real-time economic monitoring based on the payment traffic flowing within a system. It is important to note that individual payment systems do not provide a full picture of economic activity (ie an RTGS system, the focus of Project Keystone, will typically show only high-value transactions, while instant payment systems (IPS) will show lower-value payments). Rather, the analysis modules developed here are focused on trends observed within the payment system that may suggest overall shifts in the economy.

Traditional economic indicators are published with a time lag due to the need to collect and validate the data. Payment data can assist by enabling faster data collection, with increased granularity, giving visibility to overall market trends.

Four components were developed for economic monitoring.

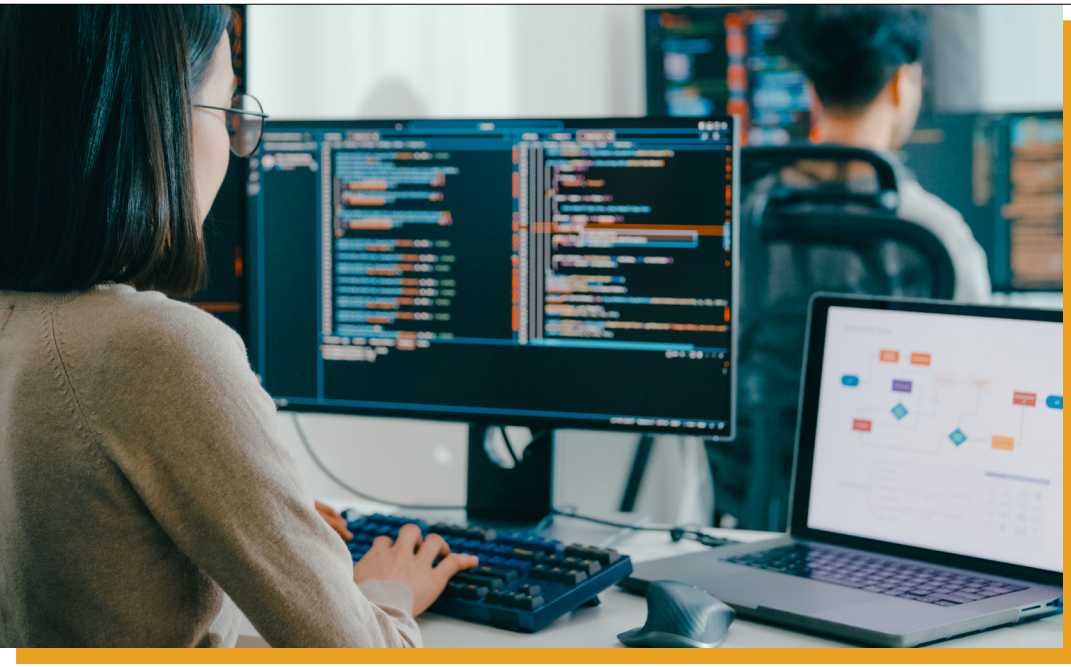
- First, Keystone enables PSOs to analyse the value of transactions by purpose code over time. Regardless of which purpose code is used, this visualisation shows the aggregate use of the code and can be filtered to display individual institution data.
- For more granular analysis of specific purpose codes, two use cases were selected:
  - A more detailed analysis of housing transactions was created, displaying transactions related to housing loan repayment, loan dispersal and loan closure. This analysis enables analysts to more easily understand the state of the jurisdiction's housing market, including the volume of house purchases and outstanding mortgages.
  - Similarly, a more detailed analysis was created to explore card spending using the card bulk clearing purpose code. This purpose code is used by merchant acquirers in their payments to businesses. Importantly, these data are exclusively at the aggregate level, allowing analysis of card spending trends without the need for any personal information on card holders. For a similar example (conducted without the use of purpose codes), see Bank of England (2025).
- Finally, Keystone provides an analysis of cross-border transactions. By parsing the structured address information within a payment, the system will determine to which country the transaction originated or was sent (Duffy and Sanders).

While the use of payment data for economic monitoring is not a novel concept, the introduction of purpose codes makes the analysis significantly more reliable and attainable to analysts. Prior examples, such as the Bank of England's debit card data series, were required to carefully filter the data based on other data points, such as account numbers, within the payment messages to obtain insights into the desired economic metrics.

Fraud analytics

- The monitoring of fraudulent transactions by the PSO can be enhanced using the ISO 20022 data set. If fraud is identified by one of the institutions in the payment chain, the payment recipient will then return the transaction via a PACS.004 return of funds message using a fraud-related reason code. Project Keystone enables the analysis of messages that were later returned due to fraud.
- Allowing PSOs to identify the most common senders of fraudulent messages and potentially providing an improved data set of fraudulent transactions will bolster future work in fraud detection. BIS Innovation Hub projects such as Hertha and Aurora, which focus on financial crime detection, have discussed the issues with the availability of financial crime transactions that are used to train machine learning models.

Project outcomes



The integration of the enhanced data set provided by ISO 20022 with the advanced analytics capabilities of Project Keystone offers significant value to PSOs. This synergy is achieved through several key mechanisms.

ISO 20022 introduces a standardised and enriched data format that supports consistency of data across various financial systems. This standardised data structure facilitates more precise and comprehensive analysis compared with prior standards, thereby improving the quality of insights derived from transaction data.

Project Keystone capitalises on the real-time nature of payment data, which is critical for timely decision-making and operational efficiency, allowing PSOs to monitor transactions as they occur, identify emerging trends and respond promptly to potential issues.

Keystone can empower PSOs to develop bespoke analytical frameworks tailored to their specific requirements. This customisation ensures that the analytical tools are relevant and effective for diverse use cases. Additionally, Keystone provides predefined analytical modules that facilitate rapid insight generation.

By establishing a foundational data layer, Keystone paves the way for future analytical use cases that may not be currently envisioned.

As the financial landscape evolves, new analytical needs will emerge. Keystone's adaptable framework ensures its capacity to accommodate these future requirements, making it a sustainable long-term solution for data analysis. It is important to note that while Keystone can provide significant value with a minimal implementation of ISO 20022 (eg in jurisdictions that do not yet mandate purpose codes, or the full use of the highly structured data set), Keystone's greatest benefits will be realised by payment systems that implement the standard fully.

Keystone has focused on only a subset of the possible analytics use cases that could be derived from the richness of the ISO 20022 standard. Future improvements to the project could focus on expanding the number of pre-build analytic use cases. Additional areas for future development relate to the provision of additional information to augment the payment message. For example, incorporating data from BICs and LEIs would allow for greater understanding of which entities are included in transactions.

Acknowledgements

Project sponsors

Francesca Hopwood Road,
London Centre Head,
BIS Innovation Hub

Mark Streather, Policy Manager,
Bank of England

Bank for International Settlements

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IT: Rudolf Biczok, Darko Micic,
Michael Stutz

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Mark Choi (CPMI)

Bank of England

Project board members: David Copple,
James Saunders

Reviewers: Victoria Cleland,
Tom Mutton, Elina Rage

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