ISSN 1914-0568

PAYMENTS CANADA PAIEMENTS CANADA

Payments Canada Discussion Paper No. 5 – June 2016

Clearing and Settlement Systems from Around the World: A Qualitative Analysis

By Michael Tompkins, Payments Canada Research Unit, and Ariel Olivares, Bank of Canada

THE RESEARCH — SIMPLIFIED

We studied 27 countries around the world that have modernized their payments systems. While many shared the same features and offerings, each took a unique approach to modernization. The research validates the need for a holistic, multi-system approach.

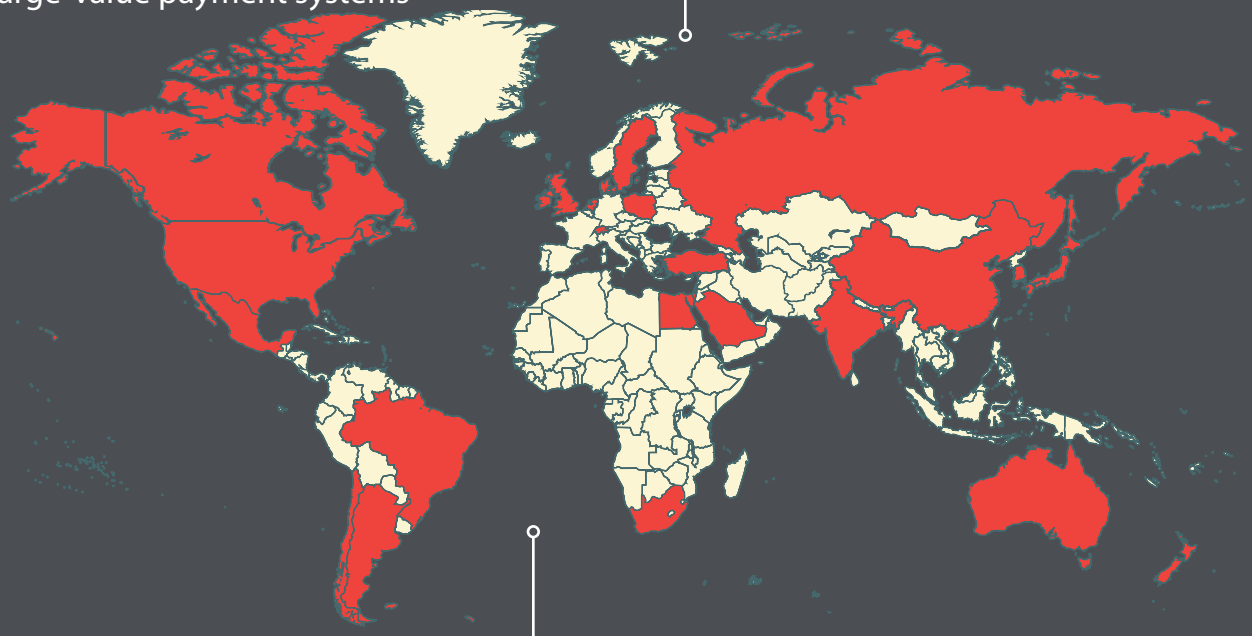
THE FINDINGS

3 GLOBAL INFRASTRUCTURE TRENDS

- Most countries have added a new real-time retail system
- All have enhanced or built a batch retail system
- The majority have made upgrades to their large-value payment systems

5 COMMON ATTRIBUTES IDENTIFIED

- Widening access to core payment systems
- Increased functionality through centralized systems
- Greater interoperability between financial market infrastructures
- Real or near real time access to funds
- Strengthening risk management



CORE SYSTEM CONFIGURATIONS ARE SHAPED BY EACH COUNTRY'S

- Public policy objectives
- User needs and interests
- Legacy payment system capabilities
- Unique modernization objectives

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Clearing and Settlement Systems from Around the World: A Qualitative Analysis

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We thank James Chapman, Carol Ann Northcott, Miguel Molico, Neville Arjani, Carol Brigham and Paul Miller and for their contributions, as well as colleagues at Payments Canada and the Payment System Oversight Division at the Bank of Canada who actively engaged in this work. We are also thankful to the members of the Retail Payments Working Group at the Committee on Payments and Market Infrastructures (CPMI) of the Bank of International Settlements, as well Andrew Rodgers of the Reserve Bank of New Zealand, for their invaluable advice in validating country-specific references and data.

ISSN 1914-0568

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Résumé

Le Canada poursuit sa réflexion afin de définir la voie qu'il choisira pour moderniser ses systèmes de paiement de base. C'est dans ce contexte que s'inscrit notre tour d'horizon de systèmes de paiement de base étrangers. Nous étudions des systèmes présents dans 27 territoires formant un échantillon géographique diversifié. Trois niveaux d'analyse sont appliqués. Nous identifions dans un premier temps les différents types de systèmes de base avant de les examiner et de déterminer comment se répartissent les systèmes à l'intérieur de l'échantillon. Nous observons que la plupart des pays se sont dotés d'un nouveau système de paiement de détail en temps réel, que tous disposent d'un système de traitement par lots des paiements de détail, et que dans la très grande majorité des cas, des améliorations ont été apportées aux systèmes de transfert de paiements de gros montant. Nous évaluons ensuite quels changements ont permis d'améliorer l'accès, la fonctionnalité, l'interopérabilité, la rapidité d'exécution et la gestion des risques. En dernier lieu, une analyse de l'architecture de plusieurs systèmes de paiement de base utilisés sur les territoires de l'échantillon révèle quatre configurations distinctes. Ces principales configurations témoignent des différences existant entre les approches retenues pour la modernisation des systèmes de paiement. Suivant les territoires, ces différences s'expliquent par les objectifs des autorités, par les facteurs de changement, les besoins, la nature des instruments de paiement et les lacunes découlant des systèmes déjà en place. Nous arrivons à la conclusion qu'une compréhension complète des objectifs de modernisation fondée sur une prise en compte des spécificités nationales est indispensable. C'est après cette étape qu'un tel ensemble d'objectifs pourra servir à la création d'un plan intégré multisystème conçu pour que chaque système de paiement de base soit modernisé dans une optique de complémentarité.

Classification JEL : E42, L14, L15, L52
Classification de la Banque : Systèmes de compensation et de règlement des paiements; Réglementation et politiques relatives au système financier; Services financiers.

Sommaire

La plupart des pays ont un intérêt commun pour la réalisation d'objectifs de politique publique en matière de sécurité et d'efficacité et pour ce qui est de répondre aux besoins de ceux et celles qui utilisent les systèmes nationaux de compensation et de règlement des paiements. Cependant, l'importance que les pays accordent à chaque objectif peut varier selon leurs priorités ou leurs plans en ce qui concerne le système de paiement. De plus, chaque pays possède son propre patrimoine de systèmes et de processus qui peuvent servir tant à accentuer qu'à freiner les facteurs qui font évoluer les systèmes de paiements. Par conséquent, peu de pays utilisent exactement la même approche pour renouveler à la base leurs systèmes de paiement.

Alors que le Canada poursuit ses discussions afin de déterminer comment il va moderniser ses systèmes de paiements, nous avons cherché à mieux comprendre les options et les approches adoptées par d'autres pays[1]. Notre principal objectif est d'offrir aux intervenants, qui connaissent les processus de compensation et de règlement des paiements, une compréhension commune des éléments clés qui caractérisent la conception d'un système de paiement.

À cette fin, nous avons analysé les systèmes de paiement de 27 pays[2], et nous avons relevé ce qui suit :

- **La plupart des pays ont mis en place (ou sont en train de mettre en place) un nouveau système de détail en temps réel.**
- **Tous les pays possèdent un système de paiement de détail en lots,** et la plupart utilisent une architecture centralisée. Les systèmes de chambre de compensation automatisée sont la méthode la plus courante. Les pays qui maintiennent un système de paiement de détail en lots sans architecture centralisée ont mis sur pied des systèmes de détail de base additionnels afin d'assurer un traitement plus rapide et une fonctionnalité accrue (p. ex. des systèmes de paiement de détail en temps réel ou des systèmes distincts pour les paiements de factures).
- **La grande majorité des pays ont apporté d'importantes améliorations à leurs systèmes de paiements de grande valeur (SPGV)** au cours des dix dernières années, laissant ce type de système au cœur des systèmes de paiements de base. La plupart des SPGV ont été modifiés de manière à comprendre des mécanismes d'économie des liquidités accompagnés de technologies visant à faciliter la gestion avancée des liquidités et à accélérer le règlement dans les systèmes de paiement de détail.

Si l'on effectue un survol des différents attributs des systèmes de paiement sur le plan de l'accès, de la fonctionnalité, de l'interopérabilité, de la rapidité des paiements et de la gestion des risques, les tendances suivantes se dégagent[3] :

- Accès : les pays s'emploient à rendre leurs systèmes de paiements accessibles à un plus grand nombre de participants directs. La croissance du nombre de participants directs va de pair avec le fait que les pays mettent à jour la technologie de leurs systèmes de paiements afin d'activer des processus et des contrôles de réduction des risques.

[1] L'Association canadienne des paiements a récemment annoncé le lancement d'un processus de consultation auprès des membres et des intervenants afin de discuter de leurs opinions sur la modernisation du système de paiement national de base. Pour en savoir plus : https://www.cdnpay.ca/imis15/fra/Publications/News/fra/res/ns/CPA_Launches_Initiative_to_Support_Modernization_of_Canada_Payments_System.aspx.

[2] Consultez l'annexe 1 pour la liste complète et un aperçu des systèmes de paiement de chaque État.

[3] J. Chapman, J. Chiu, S. Jafri et H. Pérez Saiz, « Public Policy Objectives and the Next Generation of CPA Systems: An Analytical Framework », Banque du Canada, document d'analyse de l'ACP, septembre 2015.

- Fonctionnalité : les exploitants de systèmes de paiement tirent parti d'une architecture centralisée pour mettre sur pied dans leurs systèmes des capacités avancées permettant de mettre des outils de surveillance et des outils visant à accroître l'efficacité (p. ex. des outils de gestion de liquidité) à la disposition des participants, et d'offrir aux utilisateurs ultimes des services à valeur ajoutée.
- Interopérabilité : les systèmes de paiement deviennent de plus en plus interopérables (automatisation), surtout entre l'infrastructure de base et les autres systèmes de paiements nationaux et, parfois, les systèmes transfrontaliers.
- Rapidité : la plupart des pays ont lancé (ou sont en train de créer) des systèmes de paiement de détail distincts pour les transactions de crédit directes qui donnent accès aux fonds en temps réel ou quasi réel[4]. Selon les caractéristiques inhérentes au système de détail en lots, les systèmes en temps réel peuvent avoir une utilisation plus large en étant conçus pour servir soit les paiements des entreprises soit ceux des consommateurs.
- Gestion des risques : la plupart des pays apportent des modifications à leurs systèmes de paiements afin de réduire l'exposition aux risques de crédit, notamment en rendant les règlements du système de paiement de détail plus fréquents et en accroissant la capacité de traitement des SPGV.

La grande majorité des pays ont modernisé plus d'un système de paiement de base. Ceux qui ont apporté des améliorations technologiques à plus d'un système (p. ex. à un système en temps réel et à un système de détail en lots, ou à un système de détail et à un système de gros) se sont ainsi donné des systèmes de base très interopérables, mais distincts, qui jouent des rôles complémentaires pour ce qui est d'atteindre les objectifs de la politique publique. Nous avons vu apparaître quatre configurations de systèmes distinctes :

- Des systèmes de paiements de grande valeur (SPGV) améliorés qui peuvent traiter de grands volumes de paiements de détail sont utilisés parallèlement à des systèmes de détail en lots à architecture centralisée (c.-à-d. une chambre de compensation automatisée). Selon cette configuration, le SPGV offre sécurité et rapidité, et le système en lots offre des fonctionnalités et des services accrus aux utilisateurs ultimes.
- Les systèmes de chambre de compensation automatisée sont accompagnés de nouveaux systèmes de paiements de détail en temps réel (ou quasi réel). La chambre de compensation automatisée offre des économies sur le plan des liquidités et un enrichissement des services riches assurés aux participants et aux utilisateurs ultimes, mais les fonds ne sont pas immédiatement disponibles pour les bénéficiaires des paiements. Le système de paiement de détail en temps réel permet aux utilisateurs ultimes d'accéder plus rapidement aux fonds si nécessaire.
- Les systèmes de détail en lots de règlement avant échange (RAE), auxquels s'ajoutent de nouveaux systèmes de paiement de détail en temps réel. Les systèmes RAE utilisent un processus de règlement et de détail intégré afin de réduire au minimum le risque de crédit, tout en offrant la possibilité d'améliorer la rapidité et la fonctionnalité des articles en lots. Les systèmes en temps réel offrent aux participants et aux utilisateurs ultimes des options de paiement plus nombreuses et plus rapides.

[4] Nous entendons par « temps réel » des fonds qui sont accessibles au bénéficiaire en moins d'une minute après l'enclenchement du paiement, et par « temps quasi réel » des fonds qui sont accessibles entre une et trois minutes après l'enclenchement du paiement.

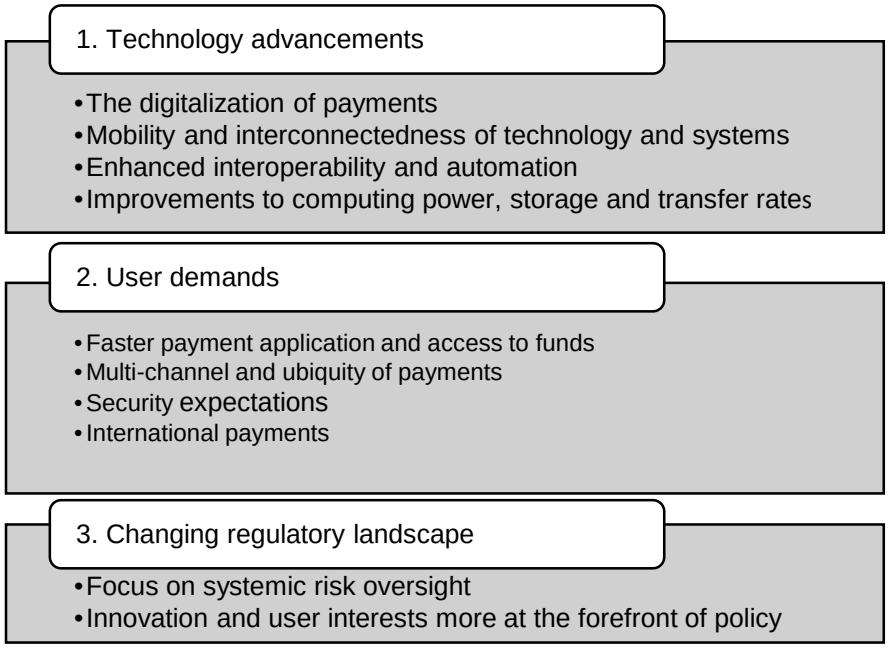
- Les systèmes de paiement de détail en lots décentralisés, auxquels s’ajoutent des systèmes de paiements de base supplémentaires ayant une architecture centralisée afin d’offrir un plus grand nombre d’options de paiement performantes et rapides.

En résumé, la plupart des pays étudiés ont amélioré (ou sont en train d’améliorer) leurs systèmes de paiements de base. Comme les tendances mentionnées précédemment le laissent entendre, il y a plusieurs approches à prendre en considération si l’on veut moderniser un système de paiement. Au moment de choisir la voie qu’il suivra, un État doit déterminer ses propres objectifs en matière de modernisation selon l’importance qu’il donne à ses objectifs de politique publique, à ses motivations et à ses besoins, ainsi qu’aux lacunes inhérentes à ses systèmes patrimoniaux. Une bonne compréhension des objectifs de la modernisation, articulée à partir des circonstances propres au pays, peut constituer le fondement d’un plan multisystème global destiné à moderniser le système de paiement de base.

Introduction

Market and regulatory forces are driving demands for new payment products and services and providing an impetus for innovation in core payment systems around the world. Modernization initiatives have spread in response to a host of drivers that can be summarized in three broad categories: new technologies, evolving user demands and the emergence of a more stringent regulatory landscape. [1]

Drivers of payment system modernization



From a public policy perspective, most jurisdictions share a common interest in pursuing the promotion of safety, efficiency and user interests. However, each jurisdiction can be viewed as applying a distinct weight to each public policy objective, according to the jurisdiction's priorities or payment system agenda. In addition, every jurisdiction has its own legacy systems and processes, which may serve to either magnify or blunt the force of each driver. As a result, few jurisdictions have taken the exact same approach to renewing their core payment systems.[2]

As Canada continues to engage in a national dialogue on a payment system modernization strategy to best meet its public policy objectives, we set out to better understand the options and the prevalence of the approaches taken in other jurisdictions.[3] To accomplish this, payment systems were analyzed in jurisdictions in the largest economies from each of the major geographic regions of the world, and in jurisdictions with innovative approaches to improve payment clearing and settlement.

[1] Details may be found in the T. Asdrubolini, S. Jafri and M. Tompkins, *2014 Environmental Scan: Global Trends, Challenges, and Impacts on Canada*, Payments Canada, July 2014.
[2] For a definition of core payment system, see Appendix III.
[3] Payments Canada recently announced the launch of a consultation process with members and stakeholders, to discuss views on modernization of the core national payments system. For more see: https://www.cdnpay.ca/imis15/eng/Publications/News/eng/res/ns/CPA_Launches_Initiative_to_Support_Modernization_of_Canada_Payments_System.aspx.

This paper outlines our observations, organized into three parts. In Part I, we introduce our country sample, discuss the different types of core payment systems in each jurisdiction and explore the most prominent payment system types found. In Part II, we analyze the core payment system upgrades that have improved the system attributes and features found in our sample. In Part III, we discuss how the configurations of multiple core payment systems have affected system renewal in each jurisdiction and have improved the achievement of overall public policy objectives regarding payment systems.

Part I: Core Payment System Analysis

1.1 Jurisdictions surveyed

This paper examines the core payment systems found in a total of 27 different jurisdictions (plus Canada) to establish trends and commonalities. These jurisdictions encompass a broad range of geographic regions and include advanced and emerging economies. The diversity of jurisdictions helps to provide a balanced perspective and a sense of the magnitude of the trends occurring in core payment system designs.[4] Throughout the paper, we focus on 10 selected countries to compare and contrast with Canada in more detail across batch retail systems, expedited retail payments systems (ERPS) (real-time payment systems) and large-value payment systems (LVPS) (each described in **Section 1.2**). These 10 countries (**Figure 1**) help to illustrate the similarities and differences in specific core payment system features and provide a consistent and manageable comparator group across our varied analyses.

Figure 1: Core payment systems of the 10 primary countries analyzed (plus Canada)

Country	Core payment infrastructure			Core system changes
	Batch retail	**Real-time systems**	**LVPS**	
Australia	BECS (decentralized batch)	NPP (due in 2017)	RITS	New real-time ERPS (NPP or new payments platform) for credit transfers scheduled for implementation in 2017. Australia has also made changes to its decentralized retail batch system (BECS), including settlement five times a day. Its LVPS is being updated to support retail system settlement processes and mechanisms.
Denmark	-Sumclearing (decentralized batch) - Intradagclearing (SBE)	Straksclearing	Kronos	New ERPS (Straksclearing) and a batch retail system (Intradagclearing) were added in 2014, to complement the decentralized batch retail system (Sumclearing). Batch processing options now include same-day or five times daily settlement, depending on the system. The LVPS (KRONOS) is also undergoing modernization to support the retail systems, optimize liquidity and improve risk management (KRONOS2 2017).
Japan	Zengin		BOJ-NET	Since 1973, the Zengin retail payment system has evolved to include innovative features to support batch and single item direct credit transaction clearing in near real-time. Further Zengin upgrades will enable 24x7 availability (in 2018). Japan also upgraded the LVPS, extending operating hours, and integrating the LVPS with the Zengin system to improve efficiency and credit risk management.
Mexico	CECOBAN (ACH)	SPEI—RTGS with a high capacity for retail transactions		In 2004, a domestic LVPS was developed with a capacity to clear and settle large volumes of low-value retail payments. Timeliness and participation have been enhanced since.
New Zealand	SBI (SBE)	n/a	ESAS	In 2011, New Zealand implemented a settlement before exchange (SBI) system for its batch items and intraday day settlement. The SBE is integrated with the LVPS to enable multiple settlement windows each day.
South Africa	EFT (ACH)	RTC	SAMOS	Since 2006, South Africa has implemented an ERPS and same-day settlement for batch retail and has made all core payment systems interoperable to improve efficiency and lower credit risks.

[4] For a full list of jurisdictions see Appendix I.

Country	Core payment infrastructure			Core system changes
	Batch retail	**Real-time systems**	**LVPS**	
Sweden	BGC (SBE)	BiR	RIX	Sweden has modernized its clearing of transactions in the Bankgirot system to enable frequent daily settlement windows (29 times daily). Bankgirot also implemented its new real-time ERPS system (BiR). The domestic LVPS (RIX) was upgraded in 2009.
Switzerland	PostFinance	SIC - RTGS with a high capacity for retail transactions		Since 2009, the SIC system has had upgrades to expand the number of direct participants, introduce liquidity saving tools and increase system capacity for higher volumes of retail transactions, and introduce the ISO 20022 standard. PostFinance has also undergone modernization to support ISO 20022 among other features.
United Kingdom	BACS (ACH)	FPS	CHAPS	The establishment of FPS in 2008 has been followed by the addition of value-added services (e.g., account switching, reporting tools) in the ACH (Bacs). The LVPS has been modernized for enhanced access, liquidity management and operating hours.
United States	-TCH (ACH) -FedACH (ACH)	*In planning*	Fedwire	Since 2012, system upgrades include FEDACH building toward same-day settlement (2016), and TCH is designing an ERPS.
Canada	ACSS (decentralized batch)	n/a[5]	LVTS	Payments Canada launched its modernization research and outreach program in 2015.

1.2 Core payment system types and prevalence

Core payment systems are usually classified as a being either for “large-value” or “retail” payment systems, depending on the main type of transactions processed.[6] Retail payments are typically low-value transactions generated in high volumes, such as for the purchase of goods and services and payments between individuals. The most common payment instruments cleared in retail payment systems are cheques, credit transfers, direct debits and card payments. Large-value payments are typically exchanged between financial institutions, in the context of financial market activities; generally involve large amounts; and require urgent, irrevocable and timely settlement. In this section, we take stock of the different core payment systems deployed around the world today and discuss the systems that are becoming more prevalent.

1.2.1 Retail payment systems architecture

There are four main types of payment systems that are used to exchange, clear and settle retail payments: centralized batch, expedited retail payment systems (ERPS), decentralized batch and enhanced large-value payment systems.

Batch retail payment systems are most commonly used to clear and reconcile batches of direct credit and direct debit payments and cheques. In batch retail systems, participants accumulate payment items from their clients during cycles (typically lasting several hours to a full business day) before the batches are entered into the core retail payment systems for clearing and settlement. Batch systems can be

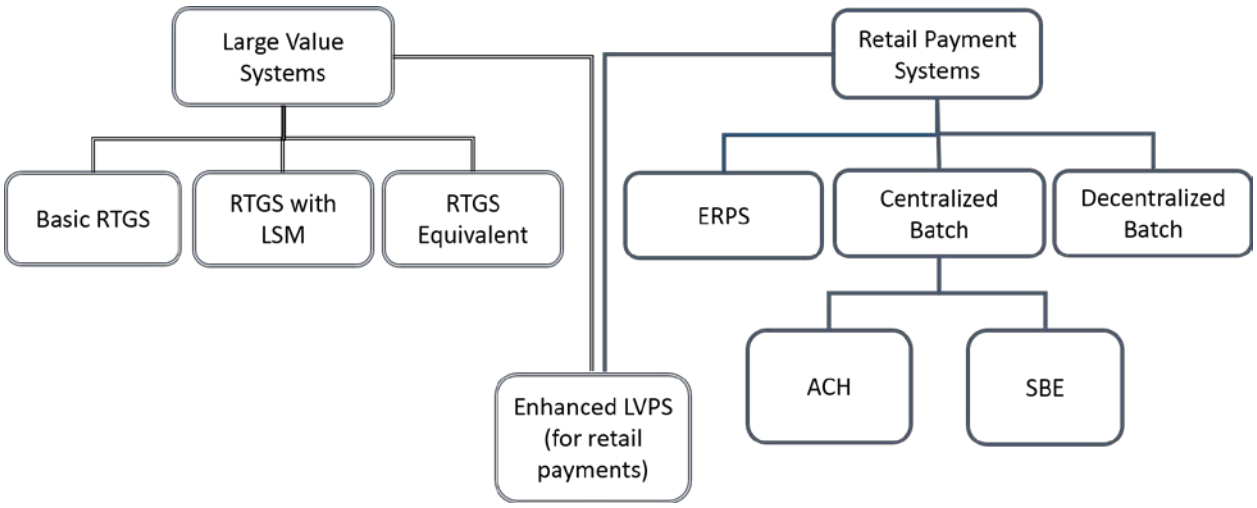
[5] See the discussion on the real-time payment systems and ERPS in this report.

[6] In a simplified way, the payment-processing cycleinvolves origination, authentication, exchange, clearing and settlement. For the purposes of this paper, the core functions are described as the clearing and settlement functions, where settlement takes place in systems using central bank money because of their importance to the financial system. See J. Chapman, J. Chiu, S. Jafri and H. Pérez Saiz, “Public Policy Objectives and the Next Generation of CPA Systems: An Analytical Framework,” Staff Discussion Paper 2015-6, Bank of Canada, 2015; Payments Canada Discussion Paper No. 2 –September 2015.

centralized or decentralized. Decentralized systems are built upon bilateral payment file exchanges that are made without a central intermediary. Centralized systems include a central node in the architecture, where the system intermediates between the exchanging financial institutions to enable the processing of files, storing of transaction data and automation of entries into settlement systems.

ERPS are typically centralized systems that exchange, clear and provide access to funds in near real time or real time. Some LVPS have an enhanced capability to process high-value and low-value (retail) payments in near real time (**Figure 2**).

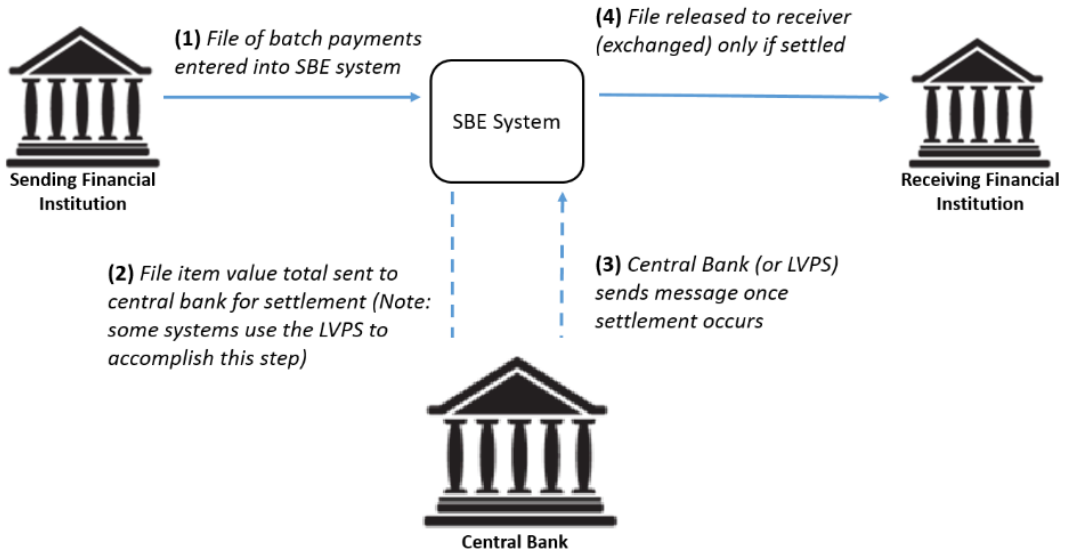
Figure 2: Types of core payment systems analyzed



Automated clearing houses (ACH)
Automated clearing houses (ACH) are centralized batch retail payment systems that are used to both exchange payment files and automatically extract file totals to calculate bilateral or multilateral participant positions throughout exchange time periods. ACH systems also typically support the settlement process by posting participant positions as entries into the national settlement accounts (held by the central bank). ACH is the most dominant form of batch clearing retail payment system analyzed, with 19 jurisdictions employing at least one ACH system as part of their core payment systems.

Settlement before exchange (SBE) batch systems
SBE systems are batch, centralized retail systems that initiate and complete settlement processes before the exchange of payment files takes place. SBE systems typically integrate exchange, clearing and settlement processes by automatically linking to central bank settlement systems (e.g., via LVPS) for settlement upon batch entry (**Figure 3**). Eight jurisdictions feature SBE systems as part of their core retail batch payment clearing systems. SBE designs have been in place for years in Russia, Sweden and Singapore and have become more prevalent as part of system upgrades in New Zealand, Denmark and Europe.

Figure 3: A typical process flow of settlement before exchange batch retail systems



Decentralized batch retail payment systems

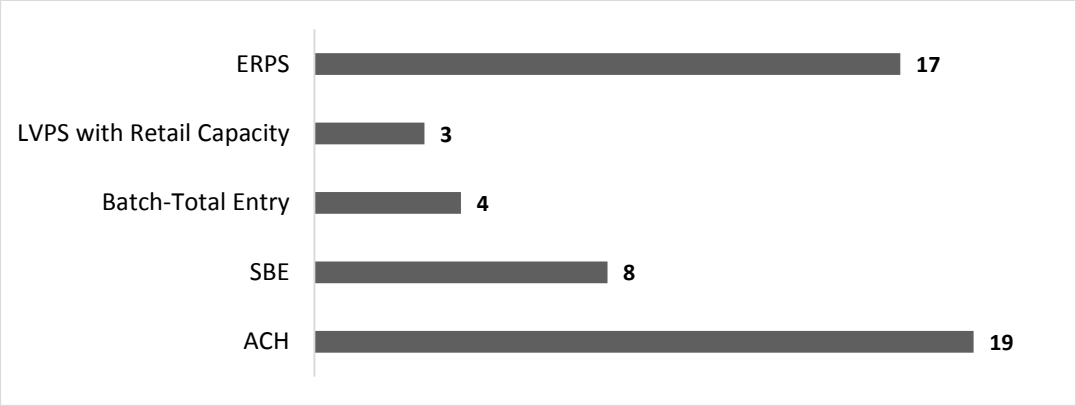
Decentralized batch systems do not use a central node for processing, validating or storing payment files. These systems require the bilateral exchange of items and the entry of item totals to take place in separate systems. The clearing system utilizes only the batch-total information provided by the participants; therefore, the role of these systems is solely to calculate net positions across participants for reconciliation of participant values for eventual settlement. In our sample, these systems are in Australia (BECS), Brazil (SILOC), Denmark (Sumclearing) and Canada (ACSS). Each of these countries (except Canada) also maintains a separate retail clearing system (e.g., an ACH and/or ERPS) to enable more-expedited transactions with enhanced remittance information (see **Section 3.1.4**).

LVPS with a high capacity for retail transactions (enhanced LVPS)

A few countries have upgraded their LVPS to process both high-value and low-value retail payment transactions. Three (of the 27) countries scanned (Switzerland, Turkey and Mexico) have structured their LVPS to serve single direct credit payments of all values, including retail transactions (Figure 4). These jurisdictions still maintain batch retail item processing through separate retail systems, but each retail system clears a smaller proportion of retail payment volumes than other jurisdictions.[7] However, while Mexico and Turkey have recently developed an enhanced LVPS with this architecture, Qatar and Saudi Arabia are transitioning away from it (i.e., by building ACH systems to offload retail volumes from the LVPS).

[7] In Mexico, the SPEI system is the LVPS with a high capacity for retail transactions, while the CCEN batch system clears all direct debits, cheques and a significant portion of the nation's direct credits (CCEN cleared 67 per cent of Mexico's retail payments volume in 2010). In Switzerland, the SIC system is the enhanced LVPS; while PostFinance handles low-value retail payments, including direct credits. PostFinance cleared nearly 70 per cent of Switzerland's retail payments volume in 2013.

Figure 4: Core retail payment systems deployed in our sample (including Canada)



Note: The total systems exceed the number of jurisdictions because many countries deploy more than one core retail payment system.

Expedited retail payment systems

In this study, we define expedited retail payment systems (ERPS) as a distinct type of retail payment system designed to provide a timely retail payment option that is integrated into core payment systems for settlement. ERPS form part of a growing broader category of instant payment initiatives designed to provide end-users with near immediate payment processing, confirmation and funds availability to the payee. This broad category of initiatives includes a mix of systems and schemes that provide fast payments and access to funds, utilizing card networks, closed-loop networks (e.g., prefunded or e-money) or core payment systems for exchange and clearing. The ERPS analyzed in this research are only those systems that involve interbank clearing, are clearly integrated with the core payment systems and directly involve central banks for clearing or settlement processes.[8] By this measure, there were 17 ERPS developed, under construction or planned in the jurisdictions scanned.[9]

The main distinguishing feature found in the ERPS compared with other instant payment initiatives (e.g., closed loop) are the interoperability with the LVPS and direct involvement of the central bank for clearing or settlement processes. The role of the central bank in ERPS is similar to the central bank role in core payment systems: to provide a managed settlement process through the provision of settlement accounts to mitigate counterparty risk. In addition, central banks may facilitate other ERPS processes and functions, such as maintaining prefunded accounts, managing collateral, facilitating netting and ensuring that the system achieves public policy objectives. Through central bank arrangements, ERPS are also interoperable with settlement systems or LVPS, enabling automated movement of transaction information for settlement purposes.

As is illustrated in **Figure 5**, the most common features of ERPS are the availability of funds to payees in near real time (i.e., within three minutes of payment initiation) and the availability of the system all day, every day (24 x 7 from the end-user's perspective).[10] In addition, with appropriate risk controls, including settlement in the LVPS with central bank money, these ERPS can support high system values and volumes and high transaction value limits, which serve a variety of use cases, including person-to-person

[8] The European Central Bank (ECB) has defined "instant payments" as electronic retail payment solutions available 24 hours a day, 7 days a week, 365 days a year that result in the immediate or close to immediate interbank clearing of the transaction and crediting of the payee's account (within seconds of payment initiation). See EPC Ad-hoc Task Force on Instant Payments, *EPC Report to the ERPB on Instant Payments*, European Payments Council, 4 June 2015. The EPC report lists 38 instant payment initiatives in Europe alone that fit its definition. Our study takes a more select view of all of the types of systems considered in the ECB report to focus on the expedited payment systems that stem from national core payment system providers and operators with direct linkages to clearing and settlement processes managed by central banks.

[9] See Appendix I.

[10] The Netherlands' Urgent Payment service provides funds within 90 minutes and is only available during normal banking hours

(P2P) payments, consumer payments to businesses and business-to-business (B2B) payments. As such, mature ERPS (such as in Chile and South Korea) have grown to account for 50 to 60 per cent of all electronic direct payments (see **Figure 5** for further examples).

In Canada, Interac's e-Transfer payment scheme shares some features and attributes with the ERPS observed, including 24-hour availability, but is slower in terms of payment processing and funds availability. Moreover, the characteristics of e-Transfer align more with the instant payment initiatives that fall outside of the scope of this research because of the absence of integration with core payment systems and the central bank in clearing or settlement processes.

Figure 5: Characteristics of select ERPS (and the e-Transfer system)

System	Direct central bank role in ERPS processes	ERPS interoperable with settlement system or LVPS	System availability	Wide use cases for business and consumers	Consumer fees	Value limits[a]	Recipient access to funds[b]
FPS (United Kingdom)	✓	✓	24 x 7	Both	Free	$460,000	Near RT
BiR (Sweden)	✓	✓	24 x 7	Consumers	Free	none	RT
Straksclearing (Denmark)	✓	✓	24 x 7	Consumers	*Unknown*	$100,000	RT
SITRAF (Brazil)	✓	✓	10 x 5	Business	Nominal	$500,000	RT
FAST (Singapore)	✓	✓	24 x 7	Both	bank set	$100,000	RT
RTC (South Africa)	✓	✓	24 x 7	Both	>$1	$27,500	RT
TEF (Chile)	✓	✓	24 x 7	Both	*Unknown*	$13,000	RT
EBT (South Korea)	✓	✓	24 x 7	Both	*Unknown*	>$1 million	RT
Zengin (Japan)	✓	✓	24 x 7	*Both*	*Free--$2* (can vary by FI)	>$1 million	RT
Express Elixir (Poland)	✓	✓	24 x 7	Consumers	$0.35 (can vary by FI)	$30,000	RT
e-Transfer (Canada)	*No*	*No*	24 x 7	*Consumers*	*$1–$2*	*$3,000*	*<30 minutes*

[a]All amounts converted to Canadian dollars. [b]"RT" (real time) = under 1 minute and "Near RT" (near real time) = >1 minute and <3 minutes.

1.2.2 Large-value payment systems

LVPS primarily move transactions exchanged between financial institutions (rather than individuals or non-financial businesses) in the context of financial market activities, which generally involve large amounts that require urgent, irrevocable or timely settlement. Thus, a system handling such payments needs to meet high safety and efficiency standards. Examples of transactions processed on LVPS are money market transactions, foreign exchange transactions and the cash leg of securities transactions. These systems are also used for the closing of settlement obligations stemming from other financial market infrastructures and ancillary retail systems (e.g., securities exchanges and card payment schemes). In our sample, we identified 19 jurisdictions that have implemented (or are building) major LVPS upgrades since 2004.

The jurisdictions from our sample, deploy primarily real-time gross settlement (RTGS) with liquidity-savings mechanisms (RTGS with LSM), which we define as RTGS with queuing and offsetting features that seek to minimize the use of liquidity to settle transactions. Two jurisdictions from our sample maintain

an RTGS system that can be described as a basic RTGS, which does not use queuing (SAMOS in South Africa and FedWire in the United States) (**Figure 6**).

Figure 6: Types of LVPS deployed in our sample, including Canada

Note: The total system exceed the number of jurisdictions because some jurisdictions deploy more than one LVPS (i.e. United States, Chile and Europe).

RTGS-equivalent systems use a different process than the basic RTGS and RTGS with LSM in that a significant portion of transactions are netted and settled at the end of each day.[11] The transactions in these systems are immediately final and irrevocable, and settlement is guaranteed through collateral and controls. These systems are therefore described as being "RTGS equivalent." In these systems, an important advantage is netting, which can provide liquidity savings. From our sample of 27 jurisdictions, four LVPS were identified as using DNS, including Canada's Large Value Transfer System (LVTS) (**Figure 7**).[12] In Europe, the United States and Chile, RTGS-equivalent systems compete for volumes against central-bank-run LVPS (each an RTGS with LSM), while, in Canada, the LVTS is the only LVPS. Another notable difference is that Canada's LVTS is used to settle the funds portion of other financial market infrastructures (e.g., the funds portion of securities settlement systems), which is not the case for the other three RTGS-equivalent systems.

Figure 7: Comparison of RTGS-equivalent LVPS

Jurisdiction	System name	Settle other FMI[a]	Transaction settlement
Canada	LVTS	Yes	End of day DNS
Chile	HVPCH	No	DNS, with real-time multilateral and bilateral offsetting
Europe	EURO1	No	End of day DNS
United States	CHIPS	No	DNS, with real-time multilateral and bilateral offsetting

[a]System is used to conduct final settlement for other financial systems, or national retail payment systems

[11] The RTGS with LSM refers to tools that process transactions in either real time or in a deferred mode by leveraging the capabilities of liquidity saving mechanisms (LSM). This "deferred" process occurs in very short intervals (from a few seconds to a few minutes), in contrast to the longer interval that takes place in RTGS-equivalent systems (usually by delaying settlement to the end of day or even the next day).

[12] The LVTS offers two tranches to leverage liquidity differently and uses end-of-day multilateral DNS for final settlement.

Part II: Key Trends and Developments in Payment System Attributes

To compare the distinctive features of payment systems in the countries scanned, we organized our analysis around five key attributes that broadly characterize the design of core systems. These attributes (established in previous research) are access, functionality, interoperability, timeliness of payment and risk management.[13]

2.1 Access

Access refers to the ability of financial institutions and other payment service providers to participate in the core payment system infrastructure. Public policy objectives typically strive for open and fair access conditions that foster competitive conditions and a more efficient system. Some systems provide rules for only direct participants, while others provide rules for direct and indirect participants. If explicit rules are in place guiding the conditions for indirect participation, the system has formal *tiering arrangements*. In systems without formal arrangements, indirect participants must negotiate the terms for system access individually with direct participants. [14]

Restrictions on the number of direct participants may provide certain advantages. On the one hand, fewer participants can help in developing scale economies by increasing volumes processed by each participant, leading to cost reductions and fostering trust with each other. On the other hand, limited direct participation increases concentration risk and the risks involved with the failure of a direct participant. In addition, limited participation can place the indirect participants at a competitive disadvantage because of the need to rely on direct participants that are also competitors. When a small number of direct participants provide access to large numbers of indirect participants, concerns might arise as a result of insufficient competitive conditions for direct access services.[15] Such risks and concerns have prompted some financial authorities to promote more direct participation.

A full analysis of the approaches taken and their results is beyond the scope of this report. However, in our primary sample of 10 countries, we found that nearly all currently have explicit policies or objectives in place to expand direct participation in their batch retail systems and LVPS. Larger numbers of direct participants bring risk and complexity. Indeed, in most jurisdictions with objectives to expand participation, risk-management-related upgrades to core payment system technology were found. Below we look at the some of the drivers for increasing access and assess how access has been affected by system modernization efforts.

2.1.1 Retail systems access

Increased participation in retail systems has been driven by reforms enabling a greater number of banks and non-traditional players (e.g., non-deposit-taking institutions) to become direct system participants. Jurisdictions in Europe generally have a large number of direct participants, which can be attributed, in part, to the implementation of Single Euro Payments Area (SEPA) guidelines and the Payment Services Directive (PSD). [16] Following are some country examples:

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[13] Chapman et al. 2015.

[14] Direct participants are those listed as such by the payment system providers and operators. In most cases, direct participation includes payment exchange, clearing, reconciliation and settlement processes.

[15] Moreover, even when alternative access providers are available, the cost and technical complexities from switching providers may be too burdensome, thus discouraging indirect providers from changing direct service providers. For a more detailed discussion on concerns about anti-competitive practices stemming from tiered participation arrangements, see Financial Conduct Authority Payment Systems Regulator, *Access to Payment Systems (Supporting Paper 4)*, PSR CP14/1.4, (November 2014), available at https://www.psr.org.uk/sites/default/files/media/PDF/psr-cp14-1-4-sp4-access-to-payment-systems.pdf.

[16] The PSD and PSD2 have introduced new provisions to facilitate access to non-bank entities, with the expressed goal to increase competition and efficiency in the payments market. The PSD and PSD2 harmonize regulations across SEPA countries, covering, among other things, non-bank provider licensing and accommodation to provide payment services. The PSD does not mandate how to accommodate the

- In Sweden, the BGC system has 22 direct participants, including a non-bank government agency, and 62 indirect participants.
- Denmark has 51 direct participants and 43 indirect participants in its Sumclearing.
- In the Netherlands, Equens has 61 direct participants, including non-bank deposit-taking institutions.

In our 10-country sample, nearly every batch retail system has followed an explicit regulatory directive or operator objective to increase direct participation.[17] Only in Mexico were we unable to find an explicit policy for the CCEN system.[18] In every country with plans for expanded retail system access, we also observed recent system upgrades aimed at reducing credit risk. For example:

- In New Zealand, a key driver for the establishment of the SBI batch retail system (using SBE processes) was to reduce credit risk to safely facilitate international banks as direct participants.[19]
- With the introduction of the China National Advanced Payments System (CNAPS2), China established over 268 direct participants in its national ACH, while managing credit risk with collateralization and same-day settlement.
- In Japan, upgrades to Zengin provide system collateralization and automated routing of transactions above 100 million yen (about $1 million CAD) into the LVPS, enabling 142 direct participants to exchange single item and batch transactions in near real-time.

To assess the impact that recent policies regarding system access have had, we looked at the number of transactions per direct participant in each batch retail payment system (**Figure 8**). Overall, we found that there were an average of 72 million transactions per direct participant and a wide range of volume-to-participant ratios. The batch retail systems in the United States (FedACH) and Mexico (CCEN) had the least volume relative to their number of direct participants (1.3 million and 4.7 million items, respectively), signifying a low degree of concentration and a broad range of direct participants. Canada (ACSS), the United Kingdom (Bacs) and Australia (BECS) had the most transactions per participant by sizable margins, suggesting that these systems have the least number of direct participants (i.e., greater tiering) relative to the volume processed through each system.[20]

non-bank providers, for example, which non-bank providers should be given direct or indirect payment system access. Each system/jurisdiction has been left to determine on their own how to best accommodate the non-banks in their systems. SEPA and peripheral SEPA countries have aligned domestic payment systems with the PSD since domestic central banks aim to keep pace with ECB established norms. See *Barriers to Access to Payment Systems and Proposed Actions: Special-Purpose Note,* the World Bank, 2013.

[17] Excluding Switzerland's PostFinance, which is essentially a system built to serve a single, very large bank. For more information on PostFinance, see Committee on Payment and Settlement Systems (CPSS), *Payment, Clearing and Settlement Systems in the CPSS Countries,* Bank for International Settlements (BIS), September 2011.

[18] Mexico operates under a central bank directive for expanding access in its SPEI system (enhanced LVPS), which clears many retail payments.

[19] G. Vaughan, "Banks Eye New Payments System with Multiple Settlements per Day Instead of Just One," www.interest.co.nz, 17 February 2011.

[20] Debit and ABM transactions were removed from the ACSS to make it more comparable with the payment volumes cleared in the other systems.

Figure 8: Country comparison of batch retail system transaction volume and direct access[21]

Country/System	Policy or objectives to increase access	Number of direct participants	Millions of transactions per direct participant	Core system risk-mgmt. upgrades
Switzerland (PostFinance)[a]	n/a	n/a	n/a	n/a
United States (FedACH)	✓	7,866	1.3	✓
Mexico (CCEN)	-	29	4.5	-
Japan (Zengin)	✓	142	11.0	✓
Denmark (Sumclearing)	✓	51	39.2	✓
Sweden (BGC)	✓	22	47.6	✓
South Africa (EFT)	✓	23	64.7	✓
New Zealand (SBI)	✓	9	85.1	✓
Australia (BECS)	✓	14	190.5	✓
Canada (ACSS)[b]	**-**	**12**	**227.4**	**-**
United Kingdom (Bacs)	✓	16	365.1	✓
Mean	***103.7***			
Median	***56.2***			

[a]The PostFinance payment system is essentially a very large bank that processes most of its payments in an internal system, between its client payors and payees, and does not publish participant data.
[b]To make ACSS comparable with the other systems, debit card and ABM volumes have been removed; most systems clear only direct debits, direct credits and cheques.

2.1.2 LVPS access

LVPS usually place a higher priority on safety, security and resilience controls, when compared with retail payment systems, because of the larger values and criticality of the transactions. Despite this fact, the numbers of participants in LVPS have been on the rise as these systems are renewed and a greater regulator emphasis is placed on direct participation. All 10 of the countries in our sample have an explicit policy in place for increasing direct participation in the LVPS. Participation has provided an impetus to upgrade LVPS technology to provide for improved risk management and greater volume and speed capacity to move transactions through more-complex risk controls for settlement (discussed in detail in **Section 2.2.2**).

Here again the European jurisdictions are establishing greater numbers of direct participants, for example:

- In Switzerland, the core payments system (SIC) has 412 direct participants, including ancillary payment systems and payment service providers.
- Denmark has 94 direct participants in its recently upgraded LVPS.
- EURO1 has 62 direct participants and has set up formal tiering for direct participant branches and subsidiaries ("sub-participants").

[21] Most data found in the table are from Committee on Payments and Market Infrastructures (CPMI), *Statistics on Payment, Clearing and Settlement Systems in CPMI Countries,* BIS, September 2015.

- TARGET2 has 1,007 direct participants and 837 indirect participants (covered by formal tiering arrangements). In addition, a new level of formal participation has been added, with 509 small bank "Internet participants."[22]

In other jurisdictions, LVPS direct participation is also growing along with system upgrades, including the following:

- Mexico's SPEI has grown direct participation to 98, including non-banks, ancillary payment systems and a telecom services provider.[23]
- In the United Kingdom, the Clearing House Automated Payment System (CHAPS) has grown its direct participants to 22 (up from 17 in 2011) and now includes volume thresholds beyond which direct access is required.
- In Australia, the Reserve Bank Information and Transfer System (RITS) has 89 direct participants (76 banks and 13 non-banks), up from 67 participants in 2008.

Figure 9: Country comparison of LVPS transaction volume and direct access[24]

Country/System	Policy or objectives to increase access	Number of direct participants	Millions of transactions per participant	Core system risk-mgmt. upgrades
Denmark (KRONOS)	✓	94	0.01	✓
United States (Fedwire)	✓	7,866	0.02	✓
Japan (BOJ-NET)	✓	473	0.04	✓
Australia (RITS)	✓	89	0.12	✓
New Zealand (ESAS)	✓	21	0.12	✓ (pending)
Sweden (RIX)	✓	30	0.14	✓
South Africa (SAMOS)	✓	23	0.28	✓
Canada (LVTS)	**-**	**17**	**0.46**	**-**
Switzerland (SIC)	✓	412	1.04	✓
United Kingdom (CHAPS)	✓	22	1.66	✓
Mexico (SPEI)	✓	98	2.68	✓
Mean		***0.60***		
Median		***0.14***		

Relative to volume, high direct participation rates are observed in Denmark, the United States (Fedwire) and Japan, where each system has less than 50,000 transactions per direct participant (**Figure 9**). If Switzerland and Mexico's LVPS are put to the side, because of their large volumes of low-value retail

[22] Internet participants enable small institutions with low volumes to participate without using the SWIFT interface. European Central Bank, *TARGET Annual Report 2014,* June 2015: 33.
[23] CPMI, *Non-Banks in Retail Payments*, BIS, September 2014.
[24] Most data found in the table are from CPMI, September 2015.

payments, the United Kingdom (CHAPS) and Canada (LVTS) have the least number of direct participants relative to their system volumes (about 1.66 million and 500,000 items, respectively). However, even though the LVTS is below the mean of 600,000 items per participant (and well below the 1.66 million items per participant in CHAPS) the data suggest that both Canada and the United Kingdom have more-concentrated direct participation (i.e., greater tiering) than is observed in most of the other countries in this sample.

2.2 Functionality

For the purposes of this paper, functionality refers to the features of the core infrastructure beyond the tasks performed for clearing and settlement. These additional features enhance services for payment system participants and enable end-user services (mostly for corporate and business clients). We observe this attribute being advanced via ERPS, LVPS and upgraded retail batch systems using centralized payment system architecture.

2.2.1 Retail systems functionality

Every payment system involves the exchange of standardized payment files or items between participants, but centralized architecture can provide for more potential functionality than decentralized systems. Obvious examples include the functionality in LVPS systems where single transaction item processes use functionality to automatically validate, route, report and send messages to participants for each transaction. Similar functionality can also be found in today's ERPS systems for individual or small batches of direct credits. However, we observe the functionality attribute is most affected in jurisdictions that have made functionality enhancements to their centralized batch systems.

Functionality in batch systems serves a variety of payment instruments and much higher transaction volumes. The prominent examples of the advancements in ACH and SBE batch retail system functionality are discussed below at three distinct levels, system capabilities, participant tools and end-user services.

Figure 10: Examples of centralized batch payment systems with high functionality

Country/System	System capabilities	Participant tools enabled	End-user services enabled
United States – FEDACH (ACH)	-Batch file sorting -Batch file routing -Item validation -Data capture -Automated messages and reports -Standardized remittance information -Supports vast numbers of users	-Unsorted batch exchange -Error and fraud detection -Automated reconciliation and submission to LVPS for settlement -Real-time monitoring tools -Automated messages and reporting	-Intraday reporting for treasury management -Automated notifications and messages -Automated accounts receivable reconciliation
United Kingdom – Bacs (ACH)	-Batch file sorting -Batch file routing -Data capture -Automated messages and reports -Standardized remittance information -Supports vast numbers of users -End-user account database -Interoperability	-Unsorted batch exchange -Error and fraud detection -Automated reconciliation and submission to settlement system (RTGS) -Corporate participation and interface for messaging and services -Automated messages and reporting -Account-switching service reduces errors and returns, generates automatic messages for participants	-Intraday reporting for treasury management -Automated notifications and messages -Corporate interface for direct item entry into Bacs -Automated accounts receivable reconciliation -Account-switching service: no need to update automatic payments (inbound or outbound)

Europe – STEP2 (SBE)	-Batch file sorting -Batch routing -Data capture -Automated messages and reports -Single item extract and route -24 x 7 availability -Standardized remittance information via ISO 20022 -Supports vast numbers of users -End-user account database	-Unsorted batch exchange -Error and fraud detection (verifies against account database) -Automated reconciliation and submission to LVPS for settlement -Automated messages and reporting -Automated routing of single items for cross-border transactions -Account-switching service reduces errors and returns, generates automatic messages for participants (optional functionality currently used for domestic transactions in Italy)	-Intraday reporting for treasury management -Automated notifications and messages -ISO-compliant remittance information -Automated accounts receivable reconciliation -Account-switching service: no need to update automatic payments (currently only in Italy)
Sweden – BGC (SBE)	-Batch routing -Item validation -Data capture -Automated messages and reports -Standardized remittance information -End-user account database -Both bilateral and multilateral clearing	-Error and fraud detection (verifies against account database) -Automated reconciliation and submission to LVPS for settlement -Automated messages and reporting -Flexibility for bilateral arrangements	-Intraday reporting for treasury management -Automated notifications and messages -Automated accounts receivable reconciliation -Electronic invoicing

System capabilities and participant tools

Rich batch system functionality begins at the system level, with capabilities that enable potential functionality for participants and end-users. At the heart of the functionality of a centralized batch retail system is the capacity to sort, validate and route payment batches to destined financial institutions. The more that is done by the system, the less that needs to be done by the participants. For example, if the system can scan individual payment items for fraud and errors, participant back-end processes will not have to. Systems can also have capabilities to capture and disseminate data from the files that are processed and use the information to provide automated reports, messages and alerts to participants. Another key aspect is the capacity to move large files, with rich remittance information, and to facilitate interaction with a large number of participants (including corporates entering items). Another capability that can contribute to functionality is the system's ability to interact with other databases and systems, which can enable features such as automated account masking, account switching and e-invoicing services (see **Figure 10** for examples).

If the system has high capabilities, it can provide rich functionality to participants, particularly with tools to enhance their efficiency. For example, participants can use the centralized architecture to:

- sort, validate and route unsorted payment batches;
- scan batches of transactions for individual transaction errors or potential fraud;
- perform automated reconciliation and entry of batch totals into the LVPS for settlement;
- use account masking to avoid fraudulent transactions;
- automatically reroute items in cases of end-user account switching, to reduce returns and errors; and
- leverage the central architecture to gather data and generate automated messages and reporting. This enables risk monitoring and regulatory compliance (e.g., anti-money-laundering, or AML/CFT, reporting) and is used to help participants manage back-end processes and their liquidity (see **Figure 10** for examples).

End-user services enabled

If a system has high functionality, participants can leverage the tools provided to better meet user interests. First, the fraud prevention, detection and notification capabilities can be translated into services that can provide benefits for end-users. Centralized architecture has been leveraged to mitigate fraud in the Zengin (Japan), STEP2 (Europe) and BGC (Sweden) systems.

End-user treasury-management tools have been developed to take advantage of the centralized architecture's data, automated messages, notifications and reports. Some systems utilize this information to provide real-time reports to participants, which can be leveraged for timely information for business clients. In payments cleared via the FedACH (United States) and Equens (Netherlands) systems, this information has been used for cash-management services that help businesses forecast their daily payment flows.[25]

Automation of key business processes such as invoicing and accounts reconciliation is possible with systems that support additional fields of remittance information in the payment messages. This information has been used to accommodate billing inputs and enable e-invoicing (electronic bill presentment and payment). The functionality to provide more payment information, together with interoperability (discussed in Section 2.3), forms the two necessary parts of straight-through-processing (STP).

Centralized systems that have the capability to interact with other databases, or over-lay services, can also enable high-value end-user services, such as seamless account switching. For example, the Netherlands' retail system (Equens) can automatically reroute end-user payments to a new bank after an account has been switched,[26] with no returns or actions required from the payment originator. Similarly, the Current Account Switch Service in the United Kingdom uses centralized databases in Bacs to forward funds automatically to new accounts and provides automated messaging to notify originators of the account changes.

2.2.2 LVPS functionality

Improved LVPS systems are increasingly leveraging advancements in technology to power sophisticated participant tools and system processes to reduce liquidity requirements and overall system costs for participants. The main innovations have taken place with improved transaction-management tools for participants, complex queuing features, and improvements in data capture and dissemination.

Participant transaction management

Upgraded LVPS are increasingly using technology to capture and manage transaction information to provide real-time information and tools to participants. Enhanced reporting and query functions provide participants with better information to inform the use of powerful transaction-management tools. These tools include liquidity reservations, transaction prioritization and timing, and active queue management, which are providing participants with greater control over their transactions, liquidity and ultimately cost.

Centralized queuing and liquidity-saving mechanisms (LSM)

If a financial institution's funds are insufficient, or other conditions governing settlement are not met, the transaction is often held by the LVPS with the use of a queuing functionality.[27] In LVPS that employ a queue, the traditional purpose has been to store payment transactions until they can be netted against an inverse payment order from the same counterparty. This process saves liquidity as settlement is completed by netting offsetting payment orders instead of using liquid resources. In recent years, the

[25] Lipis Advisors, *2014 Global Payment Systems Analysis*, Comparative Analysis, May 2014: 97–106.
[26] Account switching is a service functionality that has been actively promoted by regulatory authorities, appealing to the public policy objective to enhance competitive conditions.
[27] Most of the RTGS systems in the sample include some form of queuing tool. Notable exceptions are Fedwire and SAMOS.

queue has been a source of innovation, since queues have taken advantage of increased computing power and sophisticated algorithms to find and apply offsetting transactions faster, multilaterally and more frequently in order to optimize the use of liquidity and reduce the costs for participants. These innovations are called liquidity-saving mechanisms (LSM).

The way in which payments are released from the queue differs from system to system, depending on the algorithms used. Simple algorithms consider the queue of a single participant and release payments on a first-in, first-out (FIFO) basis. Intermediate algorithms also allow reordering or revoking of queued payments to set different priority levels or to use a bypass mechanism. Today's advanced algorithms, such as those deployed in LVPS like TARGET2 (Europe), BOJ-NET (Japan), RITS (Australia) and SIC (Switzerland) consider the queues of several participants simultaneously in short time intervals to match transactions in the settlement cycle. See examples in **Figure 11**.

LSM in these systems increase the system's capacity to settle payments through netting, thereby reducing queue lengths, speeding up the settlement process and reducing intraday liquidity needs and risks. Mexico's SPEI system runs its algorithms every five seconds to release settlement of payment orders and minimizes liquidity requirements through this high-frequency approach. Another prominent example is CHAPS in the United Kingdom, which runs a series of offsetting algorithms every two minutes to settle by matching pairs of payments in batches. In Canada, the LVTS's most prominent liquidity-saving feature is a design that allows transactions to be settled on a net basis while still meeting international credit and liquidity risk standards. The LVTS also has a less-used queueing feature, which forms another aspect of the liquidity-saving design of the LVTS.[28]

Figure 11: Liquidity-saving mechanisms in selected LVPS

System	Central queue	Liquidity-saving algorithms (for transaction off-setting	Prioritization	Other liquidity tools and features
RITS (Australia)	✓	✓	✓	Participant queue management, reservations
Kronos (Denmark)	✓	✓	No	Participant queue management, reservations
BOJ-NET (Japan)	✓	✓	✓	
SPEI (Mexico)	✓	✓	✓	
ESAS (New Zealand)	✓	✓	No	
SAMOS (South Africa)	No	No	No	
RIX (Sweden)	✓	✓	✓	Participant queue management, reservations
SIC (Switzerland)	✓	✓	✓	Reservations
CHAPS (United Kingdom)	✓	✓	✓	Participant queue management
Fedwire (United States)	No	No	No	
LVTS (Canada)	✓ (> $100 mil)	✓ (> $100 mil)	✓ (> $100 mil)	Two-tranche system
TARGET2 (Europe)	✓	✓	✓	Reservations, pooling, participant timing controls

[28] The LVTS has an LSM with an algorithm to expedite very large transactions also known as "jumbo payments" (greater than $100 million). The LVTS's jumbo algorithm will release the payment when it finds offsetting payment values. The LVTS's risk controls ensure that it can cover exposures and complete settlement regardless of how many participants default.

2.3 Interoperability

Interoperability refers to the degree of automation between systems.[29] There is a trend for core payment systems to use more automation to avoid the need for manual interventions (i.e., re-keying or re-entering information) to move transaction information across systems for payment messaging, clearing and settlement. This provides for an efficient and accurate process that can deliver timely payment information to participants and ultimately to business payor and payee systems.[30] STP exists when there is automation across all the systems involved. This streamlines processes and saves time and money for participants, users and the system as a whole.[31]

Domestically, interoperability usually links the LVPS with other financial market infrastructures (FMI), including core retail payment systems, ancillary retail payment systems and securities systems (for settlement purposes). Interoperability is also fairly common for cross-border systems that settle international payments (such as the Continuous Linked Settlement system, or CLS). Some prominent examples of highly interoperable systems include the following:

- TARGET2 is interoperable with 83 ancillary payment and security systems in Europe. It also allows seamless payment transfers across 23 jurisdictions and 2,000 participants (making it the world's largest cross-border RTGS system).
- In Switzerland, SIC is interoperable with CLS, the securities systems and retail payment systems.
- All of the expedited retail payment systems (ERPS) in our sample, e.g., the United Kingdom's Faster Payments system (FPS) and Poland's Express ELIXIR system, have automated links to a settlement systems or LVPS to perform settlement.

In large markets, some retail payment systems are also interoperable with each other, improving payment ubiquity. By linking networks, users are able to transact across each network. For example, in the United States, the two main retail payment systems (EPN ACH and FedACH) are interoperable with each other to facilitate intersystem transactions.[32] Similarly, the retail systems in Europe—STEP2, CORE and Equens—interoperate for intersystem transactions (**Figure 12**).

Interoperability can be extended internationally to facilitate cross-border payments. To achieve the level of automation and straight-through processing required, systems need to be able to "talk" to each other, either through common standards or through conversion tools that translate standards.[33] In our study, ISO 20022[34] is becoming the prominent international standard. Globally, existing systems compliant with the ISO 20022 standard can be found in the EU countries,[35] New Zealand and Japan. With greater interoperability and automation between systems and participants, wider STP (that includes businesses) is taking root in several jurisdictions, for example:[36]

[29] CPSS, *The Interdependencies of Payment and Settlement Systems*, BIS, June 2008.
[30] Security and Exchange Board of India (SEBI), Frequently Asked Questions on Straight Through Processing, available at http://www.sebi.gov.in/faq/faqstp.html.
[31] P. Hong, *Emerging Trends in Straight-Through Reconciliation*, Citibank, 2013. Available at http://www.citigroup.com/transactionservices/home/about_us/articles/docs/emerging_trends_str.pdf.
[32] In some jurisdictions, such as the United States or the European Union, there is more than one retail payment system, which may overlap in certain instruments and thus require a conduit to convey transactions from one system to the other.
[33] Switzerland's SIC system converts messages and transactions from four different standards (including ISO 20022).
[34] ISO 20022 is a global messaging standard for the financial services industry that enables participants and systems to use consistent terminology and syntax. ISO 20022 promotes interconnection between payment platforms and can facilitate automation and STP.
[35] This is largely explained by the fact that the SEPA initiative in the European Union mandated credit transfer and direct debit schemes to comply with the ISO 20022 standard by 2014 for systems in the euro area.
[36] F. de Roeck, "Early Movers Confirm: ISO 20022 Message Standards Generate Tangible Benefits," *EPC Newsletter*, European Payments Association, 13 July 2012. Available at http://www.europeanpaymentscouncil.eu/pdf/EPC_Article_237.pdf.

- Finland was one of the earlier adopters of the ISO 20022 standard for retail payments. Finnish corporations have developed automated payment reconciliation and have begun to extend STP to their international customers and partners (via STEP2, using additional characters of remittance information than the mandated 140 characters in SEPA ISO 20022).[37]

- In Sweden, the BGC has a solid foundation of STP for business-to-business transactions, using a domestic standard. Sweden has enjoyed wide provision of remittance information and automated reconciliation for some time.

In Canada, Payments Canada recently announced its plans for the implementation of the ISO 20022 standard for its core payment systems[38] to improve interoperability and provide services for participants and end-users.

Figure 12: Interoperability of core payment systems

Jurisdiction	Interoperability (automation) between financial systems				
	Retail and LVPS or Settlement System	LVPS/Settlement System & other FMI	International retail or FMI	Corporate/end-user	ISO 20022[a]
Australia	✓	✓	-	-	In development
Denmark	✓	✓	✓	✓	✓
Japan	✓	✓	-	✓	✓
Mexico	✓	✓	✓	-	-
New Zealand	✓	-	-	-	✓
Poland	✓	✓	✓	-	-
South Africa	✓	✓	✓	-	Under consultation
Sweden	✓	✓		✓	-
Switzerland	✓	✓	✓	✓	✓
The Netherlands	✓	✓	✓	✓	Under consultation
United Kingdom	✓	✓	-	✓	-
United States	✓	✓	✓	-	-
Canada	-	-	-	-	Under consultation

[a]"In development" refers to standards adopted and being worked into the systems, while "under consultation" refers to systems where the standards are still being considered.

2.4 Timeliness of payments

Timeliness refers to the duration between initiation of a payment order by the payor and the moment when the funds are made available (and irrevocable) to the recipient. This attribute has two dimensions to it: (i) time to complete the funds transfer and (ii) the hours of operation of the core systems for exchange and clearing.

Most LVPS around the world have developed real-time processing capabilities. Therefore, the focus here is on retail payment systems. While timeliness of payments is a consideration in batch retail systems, a movement toward more-frequent settlement has been driven more by an interest in improving risk

[37] CGI Group Inc., *The Drive to Electronic Remittance Exchange in Business-to-Business Payment Automation,* CGI White Paper, June 2014.
[38] Payments Canada launched a public consultation on 10 August 2015, seeking feedback on its initiative for implementing ISO 20022.

management (see **Section 2.5**). As such, the biggest impact on the attribute of timeliness observed has been through the promulgation of ERPS, with the following key drivers:

- End-user demand for faster funds availability for certain payments such as time-sensitive bill payments and other remittances and disbursements
- End-user demand for payment processes that better align with the speed of other business processes
- Regulator interest in mitigating credit risk stemming from deferred processes[39]

2.4.1 Expedited retail payment systems

In the 27 countries scanned, 17 jurisdictions have implemented or are in the process of implementing ERPS. The motivations for countries to introduce ERPS can vary, as the following examples illustrate:

- The decision to implement the United Kingdom's FPS was spurred by the UK government, upon completion of a review of payment system inefficiencies. The review concluded that the UK payment system needed to eliminate float for certain electronic payments and provide faster access to funds than the ACH (Bacs) provided (funds available in approximately three business days).
- In Australia, a central bank strategic review identified the need for a retail payment option that could provide rich information, easy routing and near-immediate funds availability on a 24x7 basis (as practicable).
- In Poland, Singapore and Sweden, the initiative to develop an ERPS system originated from within the banking community in response to perceived competitive pressures.

ERPS make funds available to the recipient in an expeditious manner, typically ranging from a few seconds to a few minutes from the time the payment order is initiated.[40] The majority of the systems analyzed make funds available in advance of settlement (e.g., FPS in the United Kingdom, Strakesclearing in Denmark and RTC in South Africa). Once it receives payment instructions, the payor's financial institution notifies the payee's financial institution to advance the funds to the recipient. Funds can be made available while the transactions are sent through the settlement process. This poses counterparty risk for the financial institutions involved; the longer the time frame between the posting of funds and settlement, the higher the counterparty risk exposure for participants. Therefore, risk-mitigation methods are employed (e.g., netting, collateral pools and loss sharing) to guarantee the transactions.

Alternatively, ERPS may settle transactions before making funds available to recipients. This eliminates counterparty credit risk but has challenges such as the need for more intraday liquidity. To mitigate the potential for a lag between the submission of the payment instructions and the actual posting of funds to the recipient's account, some systems (such as BiR in Sweden and SITRAF in Brazil) have synchronized the fund posting and the settlement processes to both occur in near real time.

In both real-time and DNS settlement models, interoperability with settlement systems allows for short windows between funds availability and settlement, mitigating counterparty risk.

2.4.2 Hours of operation

Since the LVPS is used for automated settlement of most ERPS, ERPS have influenced the operations of LVPS. To support ERPS, LVPS risk-management tools have been modified, their hours of operation

[39] *Flavors of Fast: A Trip Around the World in Immediate Payments,* Clear2Pay, June 2014.
[40] In addition, faster transactions pose new challenges for system design, maintenance and customer service. As payment processes accelerate, there is less time to conduct fraud and money-laundering checks, make sophisticated routing decisions, manage exception processes and deliver 24x7 availability—all of which might lead to risks that must be managed.

have been extended and, in some jurisdictions, separate settlement accounts have been created for the settlement of ERPS transactions.[41] Australia, the United Kingdom and Sweden are countries where there have been significant changes or enhancements to LVPS or settlement systems to accommodate ERPS (**Figure 13**). Historically, the hours of operation of LVPS payment systems were constrained to standard business hours, and transactions taking place over the weekend, after the cut-off time or on holidays were cleared and settled the next business day. Demands for extended hours for LVPS have increased as the settlement frequency of retail payment systems has increased, with ERPS a key contributor to this trend.[42]

Figure 13: ERPS impact on LVPS (jurisdictions with published details of ERPS systems)

Country and ERPS	Funds availability	Settlement time frame	ERPS hours of operation	LVPS days and hours of operation[a]
Australia (NPP in build)	RT	RT	24 x 7	15 x 5
Brazil (SITRAF)	RT	5 minutes	10 x 5	12 x 5
Chile (TEF)	RT	2 x daily	24 x 7	9.5 x 5
China (IBPS)	RT	1 x daily	24 x 7	8.5 x 5
Denmark (Straksclearing)	RT	5x daily	24 x 7	8.5 x 5
India (IMPS)	RT	1 end of day	24 x 7	9 x 6
Japan (Zengin)	RT	1 x daily	24 x 7	12.5 x 5
Poland (Elixir Express)	RT	RT	24 x 7	10.5 x 5
Singapore (FAST)	RT	2 x daily	24 x 7	10 x 5
South Africa (RTC)	RT	10 x daily	24 x 7	24 x 7
South Korea (HOFINET)	RT	1x daily	24 x 7	8.5 x 5
Sweden (BIR)	RT	RT	24 x 7	10 x 7
United Kingdom (FPS)	Near RT	3 x daily	24 x 7	10 x 5

2.5 Risk management

Risk management refers to all the processes used by payment systems and their participants to identify, assess and control risk. The most relevant types of risk for core payment systems are credit, liquidity, operational, legal and business risk. Each of the payment system attributes described above have implications for risk management. We cover some of the most obvious risk considerations under sections 2.1 and 2.2, highlighting each attribute's relevance to the management of credit risk. Below we summarize trends in retail and LVPS risk management.

2.5.1 Retail payment systems risk management

Risk-management trends in retail payment system modernization have focused on enhancements to credit risk management, where risk has been reduced through[43]

[41] Recognizing that in some jurisdictions LVPS hours of operation were already extended to facilitate CLS.
[42] In Sweden, the ERPS (BiR) is also available during weekends. However, to support transactions made over the weekend, pre-funded settlement accounts are required.
[43] D. Folkerts-Landau, "Wholesale Payments and Financial Discipline, Efficiency and Liquidity," IMF Working Paper WP/97/154, International Monetary Fund, 1997; and CPSS-IOSCO, *Principles for Financial Market Infrastructures*, BIS, April 2012: 39.

- shorter duration between funds availability and settlement (The shorter the duration, the lower the counterparty credit risk that can accumulate before settlement. This is being addressed through ERPS and more frequent batch settlement.);
- settlement before exchange processes that eliminate counterparty credit risk;
- controls such as collateralization, transaction size limits and debit caps (for both ERPS and batch); and
- enhanced reporting and monitoring capabilities (through centralized architecture).

Most jurisdictions maintain at least one batch DNS system, with recent system upgrades moving more of these batch systems to same-day or faster settlement. In the 27 jurisdictions scanned, only 9 maintain next-day (or longer) settlement for batched retail payments (including Canada's ACSS). For the same-day batch retail systems, the frequency of batch settlement varies by jurisdiction (**Figure 14**). Settlement frequency ranges from 1 to 29 times per day; Intraday settlement is the most prevalent in SBE systems.

Figure 14: Batch retail system settlement time frames, by clearing system type

Same-day or intraday settlement		
Settlement before exchange	**ACH**	**Decentralized batch**
• **SBI (New Zealand hourly)** • **STEP2 (Ireland – same day)** • **ELIXIR (Poland – 3 x daily)** • **BGC (Sweden – 29 x daily)** • **VER (Russia – 3 x daily)** • **IBG (Singapore – same day)** • **STEP2 (Europe 7 x daily)**	• EFT (South Africa – same day) • BEPS (China – intraday) • FedACH (United States – same day) • BPAY (Australia – same day scheme)	• BECS (Australia 5 x daily) • Sumclearing (Denmark same day)
Next-day or longer settlement		
(nil)	• CCA (Chile) • ACH (Egypt) • BCH (Isreal) • COELSA (Argentina) • KFTC (South Korea) • Bacs (United Kingdom) • NECS (India) • CCEN (Mexico)	• ACSS (Canada) • SILOC (Brazil)

2.5.2 LVPS risk management

Risk-management controls have changed in response to international standards established for systemically important systems, called the Principles for Financial Market Infrastructures (PFMI). The PMFI set out requirements for a common minimum level of risk management across countries, which have resulted in a convergence in risk-management controls and practices.[44]

In LVPS, risk management is being modernized by increasingly more sophisticated computing power and software that provide tools for participants to closely manage transactions, liquidity and their credit exposures. The technology is also enabling system operators to set up more-efficient controls to better mitigate risks.

[44] Established in 2012, the PFMI establish risk controls to address credit and liquidity risk and to set up minimum requirements for collateral, margin and money settlements, among other policies and procedures. The PMFI are published on the CPMI website at http://www.bis.org/cpmi/info_pfmi.htm.

In many of the jurisdictions scanned, the LVPS systems have also been upgraded to increase direct participation, interoperability and settlement speed, and to facilitate retail payment settlement (which increases volumes and values of transactions moving through LVPS). Overall, two main modernization trends are observed in the risk management of LVPS: (i) enhanced tools for liquidity management, and (ii) technology to bolster LVPS processing speed to quickly settle transactions and reduce liquidity requirements. Both are described in detail in Section 2.2.2.

2.6 Summary

Figure 15 summarizes how the core payment system changes have resulted in the advancement of payment system attributes and their potential impact on achieving public policy objectives of safety, efficiency and user interests.

Figure 15: Key core payment system attribute changes observed

Attribute	Key attribute observations
Access	• System upgrades and policy changes have been established to enable more direct participants in core payment systems. In our sample of countries, there was significant variance in the number of participants compared with system volume, but, in general, most systems have more participants than in Canada. -Some jurisdictions' regulators have allowed access to retail payment systems for non-banks. • Systems that promote larger numbers of participants have upgraded systems that enable sounder risk-management configurations to limit counterparty risk exposures.
Functionality	• LVPS and ERPS generally offer high capabilities and services for end-users. However, both LVPS and ERPS tend to serve limited retail volumes and payment instruments. • Countries that have upgraded their batch retail payment system functionality offer functionalities and services that benefit a high volume of transactions. -Higher functionality is found only in systems with centralized architecture (i.e., ACH and SBE) • For LVPS, functionality has expanded in the areas of liquidity-saving mechanisms (e.g., queue management, real-time monitoring and execution of high-speed processes).
Interoperability	• Most jurisdictions have improved the automation of clearing and settlement processes to enable interoperability across core payment systems. -Most automation has been done domestically, to link the LVPS with core and ancillary retail payment systems and other financial market infrastructures. -International interoperability is limited to certain regions (e.g., Europe). • As use of the ISO 20022 standard grows, so does the potential for international interoperability and the prospects for more straight-through processing of payment files with remittance information.
Timeliness of payments	• Demands for more rapid payments and access to funds have sparked the development of ERPS systems to provide separate clearing systems for faster retail payments. • ERPS systems have provided a catalyst for LVPS and settlement system upgrades because of: -an increase in LVPS hours of operation to enable ERPS settlement; and -the effects of ERPS liquidity and risk management.

Risk management	• The growth of more same-day and intraday settlement cycles and SBE configurations signals a general movement toward decreasing credit risk for retail payments. -DNS is still prevalent in retail payment systems but the deferred time frame is shortening. • LVPS have been adapted for more automation and frequent settlement of retail systems. -LVPS controls are being executed faster, with more participants and on higher volumes.

Part III: Multiple System Architecture Designs

Part I discusses the prevalence of the different types of core payment systems, and Part II describes the trends in the changing attributes of payment systems. However, analyzing systems in isolation misses the fact that public policy objectives can be achieved through upgrades made across multiple core systems. Below, we look at how multiple core payment systems have been changed in jurisdictions to form a combined configuration of systems (3.1) and explore how these multiple system configurations serve to address public policy outcomes (3.2).

3.1 Core payment system evolution

The primary driver for change in our sample has been jurisdictions' interest in improving public policy outcomes for retail payments, where regulators and stakeholders have sought improvements to the perceived deficiencies in legacy batch retail payment systems.

Previous to 2005, most countries structured their retail payment systems as either ACH or decentralized systems (20 of our 27-country sample). In general, these legacy systems were associated with low timeliness (next-day settlement and funds availability was typical), low access and low risk management (as result of using overnight DNS without compensating controls). While some legacy ACH systems used their centralized architecture to develop additional functionality and provide more access and interoperability with other domestic payment systems, decentralized systems typically achieved low levels of each attribute.

Comparing systems from before 2005[45] with those found in 2015, we found that 24 of the 27 countries have redesigned (or added) at least one core payment system (or have one in development)**.** Of these jurisdictions, we observed 20 that have made (or are in the process of making) major changes to more than one core payment system. [46]

- Each of the LVPS enhancements occurred in jurisdictions implementing a batch retail system upgrade or a new ERPS (e.g., Australia and the United Kingdom). Today's LVPS are often called upon to support intraday settlement of batch clearing systems, SBE systems and/or ERPS.
- Most jurisdictions with an ACH are adding an ERPS or an enhanced LVPS.
- Centralized batch systems are being upgraded for enhanced functionality and shorter settlement durations.
- Most of the batch retail systems are either ACH or SBE, which together account for 21 of the 28 primary batch retail systems found. ACH systems remain the most common type of batch retail payment system. However, SBE systems were the fastest-growing type of batch retail payment system, since almost three times as many jurisdictions deployed SBE in 2015 than in 2005 (eight versus three).
- Jurisdictions with decentralized batch systems have added other specialized retail systems (or schemes) to enhance their retail payment system options (in Brazil, Australia and Denmark).[47]
- **Figure 16** provides specific examples, using our 10 primary country comparator group, of core payment system changes that have occurred since 2004.

[45] The target year for comparison was 2004; however, in several cases, legacy systems could only be observed in years before 2004. In such cases, legacy architecture was analyzed in the year as close to 2004 as possible.
[46] Australia, Brazil*, Chile*, Denmark, Europe, Ireland, Mexico*, Japan, South Korea, Netherlands, New Zealand, Poland, Qatar*, Russia*, Sweden, South Africa, United Kingdom, United States, China, India, Saudi Arabia, Singapore*, Switzerland, Turkey* (*indicates jurisdiction with only one core system upgrade)
[47] Canada is in the process of considering modernizing its core payment systems.

3.2 Assessing attributes across multiple systems

Because one payment system cannot optimally meet all of the public policy objectives, jurisdictions employ multiple systems (i.e., LVPS, batch retail systems and/or ERPS), which combine to provide a set of system-wide attributes. As jurisdictions have upgraded their payment systems, they have done so over multiple systems, addressing deficiencies in one system with the advantages in another system. The resulting core payment system configurations can be classified into four groups, each with an LVPS at their centre:

(i) Enhanced LVPS (with a high capacity for retail payments) with ACH
(ii) ACH batch with ERPS
(iii) Settlement before exchange (SBE) batch processing with an ERPS
(iv) Decentralized systems with additional retail payment systems

Figure 16: Core payment system changes among the 10 country examples

Country	Legacy core payment systems (before 2005)		Core system changes made through 2015		
	Batch retail	LVPS	Batch retail upgrades	ERPS added/ planned	LVPS or settlement system changes
Australia	DB, T+1	RTGS w/ LSM	-5 times daily settlement for DB	Yes (in build)	Enhanced to facilitate ERPS and 5 times daily settlement of batch system
Denmark	DB, T+1	RTGS w/LSM	-T+0 for DB system -Added separate SBE with 5 times daily settlement	Yes	Upgrades to facilitate retail systems and improved liquidity-management tools
Japan	ACH, T+0	Basic RTGS	-Real-time transaction processing for batch and single item direct credits developed, creating a unique system that incorporates features of ACH and ERPS	Yes	Upgrades for higher volumes, automated routing of high-value transactions from Zengin to LVPS
Mexico	ACH, T+1	Enhanced RTGS (for retail items)	-ACH still widely used for certain instruments	-Enhanced LVPS for posting retail items in real time	
New Zealand	ACH, T+1	RTGS w/ LSM	-Replaced ACH with SBE	No	Upgrades to integrate with SBE process, further major LSM and risk-management changes expected in 2016, possibly to serve ERPS
South Africa	unknown	Basic RTGS	-T+0 ACH -Moved larger value items to RTGS	Yes	2007 RTGS upgrades for RTC and larger-value transactions moved out of retail system
Sweden	SBE, T+0	RTGS w/LSM	-Increased SBE settlement to 29 times daily	Yes	RIX was upgraded in 2009 to add new queue options, LSMs, and functionalities to support other FMI settlement (e.g., frequent BGC settlement).
Switzerland	PostFinance,T+1	Enhanced RTGS (for retail items)	-Made interoperable with LVPS -Functionality added including automated messages and ISO 20022	No	Greater participant transaction-management tools, LSM tools and adoption of ISO 20022
United Kingdom	ACH, T+2	RTGS w/ LSM	-Improved functionality (automated messaging) and access, and added account-switching service -Risk management improved through debit caps and “cover all” collateralization (2015)	Yes	Upgrades to facilitate FPS, improve access and upgrade LSM
United States	ACH, T+1	Basic RTGS & RTGS equivalent	-Real-time monitoring tools and reports -Automated messaging to end-users -Same-day settlement for direct credits and debits (2016)	Yes (in build)	- Updated risk controls, LSMs and intraday credit policies (2011) -Expanded fields for more remittance information, translation with ISO 20022 (2013)

DB = Decentralized batch retail systems
SBE = Settlement before exchange
T+“x”= Number of days after payment exchange when settlement occurs

3.2.1 Enhanced LVPS (with a high capacity for retail transactions) with ACH

This approach employs an enhanced LVPS system with a capacity to serve many retail transactions (mostly in the form of single direct credit transactions), and an ACH that clears less volume than in other system configurations.[48] Given the fast availability of funds provided through the LVPS, this combination of systems also seems to eliminate the potential need for a separate ERPS. However, only three jurisdictions in the sample use this configuration: Turkey, Mexico and Switzerland.[49]

In this configuration, large volumes are processed in the LVPS, in part, because the systems utilize some of the most advanced features to enable sophisticated queuing tools and participant transaction-management options. For example, Switzerland's SIC system uses liquidity-reservation tools, advanced prioritization options and client-specific controls (e.g., client debit caps) to help settle nearly 420 million LVPS transactions in 2013 (in comparison, Canada's LVTS settled 7.5 million transactions in 2013).[50] As such, many payments are settled through a highly risk-proofed system that can provide for fast availability of funds.

The strong risk controls in enhanced LVPS also have enabled wide access, when compared with other jurisdictions' LVPS. For example, Switzerland has more than 400 direct participants, including payment networks, non-banks and many non-domestic banks.[51] Mexico's SPEI system has 98 direct participants and is currently looking to expand access for more non-bank financial institutions.

There are disadvantages to using enhanced LVPS. In particular, higher liquidity costs result from moving large volumes of low-value payments through highly risk-proofed systems. Also functionality, such as fraud and AML/CFT monitoring may be challenging to accomplish in real-time systems. This is offset by ACH systems that provide for low-cost and slower retail payment clearing. The batch retail payment systems in these jurisdictions are used to clear cheques, as well as direct credit and debit batches, providing options for slower and lower-cost clearing. In this way, the LVPS and ACH are complementary and provide distinct instrument choices for system participants and end-users. The key attributes of this type of system architecture are summarized in **Figure 17**.

Figure 17: Enhanced LVPS architecture attributes

Attribute	Architecture implications
Access	The enhanced LVPS offers wide direct participation to a variety of financial institutions because of its strong risk controls.
Functionality	More advanced functionality can be offered through the ACH.
Interoperability	High interoperability within the architecture and other FMI.
Timeliness of payments	The enhanced LVPS can provide for near real-time funds access, while the ACH provides same- or next-day settlement and access to funds for less urgent payments.
Risk management	The LVPS provides for low credit risk for large volumes of payments. The low netting efficiency of the LVPS is offset by the ACH transactions that have longer netting durations.

[48] Switzerland's PostFinance system is not technically an ACH because its transactions are processed through internal processes (i.e., on-us). PostFinance does provide centralized transaction processing and functionality (e.g., ISO 20022) for low-value retail payments, which emulate features of ACH systems, for participants and end-users.
[49] Saudi Arabia is another example; however, it is in the process of adding an ACH and ERPS to its payment system. Similarly, Qatar has recently completed the addition of an ACH system for batch clearing.
[50] Swiss National Bank, *Monthly Statistical Bulletin September 2014*.
[51] J. Mägerle and R. Oleschak, *The Swiss Interbank Clearing (SIC) Payment System*, Swiss National Bank, February 2009: 6.

3.2.2 Batch ACH and ERPS

This configuration is distinguished by the processing of most payments in batches, through centralized ACH architecture and the inclusion of an ERPS for direct credit retail transactions. The attributes of this configuration support rich functionality through modernized ACH features, and improved overall timeliness through same-day or faster settlement with a modern ERPS. Prime examples are the payment systems of the United Kingdom, China, Saudi Arabia and the United States (once its ERPS is deployed).

The benefits of the batch ACH configuration are mainly the netting efficiencies gained through the use of DNS, as well as the value-added services found in high-functionality batch systems (i.e., error detection, fraud reduction, monitoring capabilities and a data-rich environment upon which to build STP). The configuration also provides users with an array of payment options (i.e., low-cost and slower or higher-cost and faster alternatives).

The main disadvantages of the ACH are less timely availability of funds and potentially higher credit risk, since ACH systems are among the slowest for transaction processing and settlement.[52] Delays are inherent in the process to accumulate payments in batches, and there is a further delay during the time between exchange and settlement, which might not occur until the next day (or in the case of the United Kingdom, two business days after the exchange).

The ERPS complements the ACH by providing for faster availability of funds that can lower overall configuration credit risk, although ERPS are also dependent on settlement and related risk controls. These benefits are best observed in jurisdictions such as Chile, South Korea and the United Kingdom, where the ERPS has succeeded in attracting large volumes of retail transactions. Further, in this configuration, the LVPS serves high-value and otherwise time-sensitive payments to move outside of the ACH. As a result, only the lowest urgency payments need to clear through the ACH. The key attributes of this type of system architecture are summarized in **Figure 18**.

Figure 18: ACH with ERPS architectural design attributes

Attribute	Architecture implications
Access	No clear access implications, since there are examples of high and low direct participation. ERPS have fewer direct participants than the batch system.
Functionality	ACH can provide high functionality but at typically lower speeds.
Timeliness of payments	Traditionally, the timeliness of payments in ACH systems has been slow. This has been improved in some jurisdictions through more-frequent exchange and settlement time frames and faster options with the ERPS.
Interoperability	ACH and ERPS systems are typically automated with settlement systems or LVPS for settlement purposes, removing manual interventions and errors, and increasing efficiency.
Risk management	Most of the volume is processed through the ACH in these jurisdictions, so netting efficiencies largely remain, as does the inherent credit risk. More frequent settlement of the ACH, and moving more volume through the LVPS and ERPS, can reduce credit risk.

3.2.3 Settlement before exchange batch processing and ERPS

The settlement before exchange (SBE) and ERPS approach is built around the use of a batch retail system that is integrated with the central bank settlement system (e.g., LVPS). The process

[52] Exceptions exist, including Equens in the Netherlands, which has settlement every 30 minutes.

uses automated messages between the systems to delay the exchange of payment files until they have been settled. In conjunction with an ERPS, this configuration offers a clearing system rich in features for a wide variety of use cases and participant and end-user needs. Jurisdictions using this combination include Denmark, Sweden and Singapore.[53] The benefits of this approach are the following:

- Credit risk, which is inherent in other types of DNS, is eliminated in the batch retail system, since payment exchange happens only after settlement on the books of the central bank.
- High levels of functionality and interoperability improve efficiency.
- Cost efficiencies can be gained with the netting of batched items.
- There is potential for expanded access due to the lower settlement risk in the system. For example, in New Zealand, the SBE configuration enables direct participation by international banks.[54] Similarly, in the euro zone, SBE systems, such as STEP2, provide a low-risk approach to meeting SEPA regulations for facilitating non-banks in the payment system.[55]
- While most SBE systems settle intraday, offering a high degree of transaction timeliness, the ERPS provides even faster payment options.

The main drawback is that the SBE system can slow the availability of funds, since payments must await settlement before they are exchanged. To spur faster transaction processing and access to funds, the number of settlement windows needs to be increased. However, more frequent settlement windows decrease the netting efficiency. This might explain the high variance observed in settlement windows, with several jurisdictions performing a single settlement at the end of each business day (e.g., Ireland) and others several times each day (e.g., Sweden's 29 times daily, every 45 minutes).[56] The link between funds access and settlement windows might also help to explain the expanding number of ERPS found in SBE jurisdictions, since ERPS could serve to help minimize the number of settlement windows needed in the SBE system. The key attributes of this type of system architecture are summarized in **Figure 19**.

Figure 19: SBE batch system architectural design attributes

Attribute	Architecture implications
Access	SBE systems enable high direct participation because of their strong risk-mitigation process.
Functionality	SBE systems leverage centralized architecture that can facilitate high functionality.
Interoperability	SBE systems are based on having retail systems integrated with central bank settlement systems or LVPS to enable settlement before items are exchanged.
Timeliness of payments	Timeliness is linked to the system's settlement windows, the number of which directly affect netting efficiencies; thus, it has an important cost trade-off. In jurisdictions where SBE systems have not met expectations for timeliness, ERPS systems have been introduced.
Risk management	Credit risk is very low in this configuration.

[53] STEP2 is interoperable with 14 ancillary payment systems, facilitates STP and has real-time monitoring and reporting.
[54] Vaughan, www.interest.co.nz, 17 February 2011.
[55] CPMI, *Non-Banks in Retail Payments*, BIS, September 2014: 31.
[56] Additionally, in countries such as New Zealand and Poland, batch clearing payments are settled bilaterally, so only bilateral netting occurs over the course of several hours. As such, offsetting still occurs, resulting in improved cost efficiency over systems that settle each transaction individually.

3.2.4 Decentralized batch systems with additional core retail payment systems

This configuration includes a decentralized batch system and an ERPS or other specialized retail batch payment system. Three countries from our sample—Denmark, Australia and Brazil—have upgraded their core payment systems while keeping their legacy decentralized batch retail system. Denmark has recently added a separate SBE system with intraday clearing (which is currently serving mostly bill and remittance payments) along with an ERPS. Australia has incorporated intraday settlement for its decentralized batch system, which requires batch items to be settled five times per day, is building an ERPS capable of supporting richer remittance information, and has a separate scheme for bill and remittance payments (Bpay). Brazil maintains a decentralized batch entry system that settles the following day and an ERPS that is geared mostly toward business-to-business remittance payments.[57] The key attributes of this type of system architecture are summarized in **Figure 20**.

Figure 20: Core retail systems of jurisdictions with decentralized batch retail systems

Country	Decentralized batch system	Specialized bill and remittance payment system	ERPS
Australia	✓	✓	✓
Brazil	✓	✓	
Canada	✓	-	-
Denmark	✓	✓	✓

As discussed above, most advancements in system attributes for batch payment processing are made possible by centralized architecture and their potential for rich system functionality, tools and services. Rich functionality is considered an essential element in advanced payment systems, and many of these features are not feasible in decentralized systems.[58] Where decentralized systems exist, the ERPS can provide attribute improvements, including interoperability, functionality, timeliness and credit risk.

The impact of the ERPS will depend on the volumes that can be moved to it and the use cases that can be served. In Brazil, the ERPS is geared for business remittances. Denmark and Australia maintain a separate centralized batch system for business-oriented payments (distinct from the ERPS and decentralized batch systems). The business payment orientation of these additional retail payment systems highlights a potential deficiency of the decentralized system in serving business payment use cases. The additional retail systems provide distinct payment system attributes that complement the decentralized batch system, providing improved timeliness and functionality (through a data-rich environment) for payments originating and destined for businesses.

Since Denmark's architecture is so new and Australia's ERPS hasn't come online yet, the benefits of these configurations are not yet clear. Therefore, it will take more time to better understand the benefits and trade-offs involved with maintaining the decentralized system alongside new specialized centralized architecture.

[57] Brazil's SITRAF system maintains minimum transaction amounts that are equivalent to about Can$5,000.
[58] A key finding from the the Bank of Canada and Payments Canada Working Group is that payment systems on the frontier must provide rich functionality allowing for value-added services (Chapman et al. 2015).

3.3 Understanding the interplay between batch systems and ERPS

The growth of ERPS systems found in our international sample has been one of the most important trends observed in payment system architecture. However, there has been substantial variance in ERPS uptake observed in different jurisdictions. The research suggests that the attributes of the batch retail system, including the settlement time frame, influence the drivers and potential scale that might exist for the ERPS (**Figure 21**).

The ERPS in jurisdictions using an SBE configuration primarily support consumer payments, such as P2P and mobile payments. This may be explained, in part, by the predominance of intraday settlement (and same-day access to funds) in batch SBE retail systems, which may suitably serve most of the B2B payment needs in these jurisdictions.

Jurisdictions with next-day (or later) funds access have the most widely used ERPS, with both extensive consumer and business use. Examples include Chile (with next-day batch settlement and access to funds), where its ERPS is used for over half of Chile's direct credit payments. Other examples include the United Kingdom and South Korea, with robust uptake by consumers and businesses. Conversely, in South Africa, which provides same-day funds from its EFT batch system, the ERPS accounts for only 3 per cent of the total batch system volume.[59]

In Brazil (SITRAF), Chile (TEF) and South Korea (EBT), the ERPS were developed to serve primarily business payments (bill payments and B2B). Each system therefore offers electronic alternatives to cheques through fast access to funds, rich payment information, and rules and fees aimed at optimizing system use for business transactions. Business-transaction-oriented ERPS (with at least same-day funds availability and rich payment information for remittances) are also typical in jurisdictions that maintain decentralized batch systems (Denmark, Australia and Brazil).

Figure 21: Interplay of batch and ERPS retail payment systems

Country	Batch retail settlement timing	Batch retail access to funds	ERPS more geared to consumer or business?[a]	ERPS access to funds[b]
Chile	Next day (ACH)	Next day	Both	RT
India	Next day (ACH)	Next day	Consumer	RT
South Korea	Next day (ACH)	Next day	Both	RT
Brazil	Next day (Decentralized batch)	Next day	Business	RT
United Kingdom	2 days (ACH)	3 days	Both	Near RT
South Africa	Same day (ACH)	Same day	Both	RT
China	Same day (ACH)	Same day	Consumer	RT
Singapore	Same day (SBE)	Next day	Both	RT
United States	Same day (ACH pending)	Same day (pending)	Both	Near RT
Australia	Intraday (Batch totals)	Next day	*(in development)*	RT
Sweden	Intraday (SBE)	Hours	Consumer	RT
Poland	Intraday (SBE)	Same day	Consumer	RT
Saudi Arabia	Intraday (ACH)	Same day	*(in development)*	RT
Netherlands	Intraday (ACH)	Same day	Consumer	1.5 Hours
Denmark	Intraday (SBE)	Same day	Consumer	RT

[59] Payments Now, Payments NZ, March 2015. A similar observation was made in *Payment, Clearing and Settlement Systems in the Netherlands*, CPSS Redbook, 2012, which found that payment volumes in the Netherlands ERPS (Telegiro) were dropping with the introduction of cheap and fast general direct credits via Equens (p. 331).

[a] Based on use cases and transaction limits. [b]"RT" (real time) = under 1 minute and "Near RT" (near real time) = >1 minute and <3 minutes.

3.4 Summary

Meeting public policy objectives is a multi-system endeavour. Jurisdictions that are modernizing their payments systems are making enhancements across multiple systems so that systems complement each other to optimize the achievement of public policy objectives. As a result, several general trends regarding multiple systems have emerged:

- Batch systems are being enhanced alongside the LVPS and ERPS to provide cost-efficient processing of less urgent payments (e.g., direct debit bill payments) to provide value-added functionality and to meet end-user needs through payment instrument options.
- More ERPS are being added to provide retail payment options that are more timely than the batch retail systems.
- Because of the interplay of ERPS and batch retail system attributes, ERPS are more widely used in jurisdictions that do not already have same-day access to funds in their retail batch systems. ERPS designs that take this into account can orient ERPS attributes to more of a consumer or business orientation (depending on batch system attributes and jurisdictional needs) that can improve uptake.
- Today's LVPS have been designed to move high transaction volumes and to support intraday settlement of ERPS and batch retail systems.

These trends can be observed in the four main core system configurations, where each configuration yields substantially different cross-system attributes (**Figure 22**).

Figure 22: Summary of core system configurations

Configuration	Multiple system attributes
Enhanced LVPS (with a high capacity for retail transactions) with ACH	The enhanced LVPS provides for very low credit risk at the expense of netting efficiencies and functionality. The ACH is used to clear batches, providing options for slower and lower-cost clearing with improved functionality.
ACH with ERPS	The ACH reduces liquidity costs through netting efficiencies and boosts overall efficiency, with interoperability and functionality. The ERPS provides an end-user with near-real-time payment options that can lower overall credit risks.
SBE with ERPS	The SBE approach has low credit risk, while permitting similar levels of functionality and efficiency to those presented by the ACH with ERPS design. With the addition of an ERPS, this configuration also provides for timely payment options.
Decentralized batch with additional retail systems	Decentralized batch systems can offer cost-efficient clearing, while additional retail payment systems (e.g., ACH and/or ERPS) can provide system-wide attribute improvements to interoperability, functionality, timeliness and credit risk management.

Conclusion

Most of the jurisdictions surveyed have made changes to their core payment systems to improve their system attributes. These jurisdictions have opened direct system access and improved functionality in their LVPS and batch retail system (with centralized architecture). Upgrades have also been made to systems to use real-time monitoring, automation of messages and payment information, and interoperability across core payment systems.[60] Further, ERPS systems and more frequent settlement of batch retail payment systems are improving the speed at which payees get access to their funds. Finally, risk-management processes have been adjusted to accommodate interoperable systems, more participants and higher payment volumes. Taken together, jurisdictions' efforts to improve payment system attributes have positively affected the achievement of their public policy objectives.[61]

As Canada considers modernizing its core payments system, this survey of jurisdictions provides an indication of trends and more general lessons on how to approach modernization. First, recognizing that there is no single best approach means each jurisdiction needs to assess precisely what it wants to achieve. The international sample contains many payment systems that are broadly similar but that have important distinctions in their payment system attributes. Each jurisdiction's drivers, needs, gaps and weighting of public policy priorities have helped to shape its system attributes, by presenting a unique set of modernization objectives. For example, in Mexico, the SPEI system was shaped in part by a public policy objective for a safer payment system, pressure for increased competition (expanded access), and demands for straight-through processing and faster funds access from end-users. Similar motives were behind the United Kingdom's Faster Payments system; however, in the end, differing modernization objectives resulted in very different system attributes and architecture.[62] This example also illustrates the importance of jurisdictional considerations and factors when assessing the most suitable system attributes to move forward.

Some jurisdictional differences can be traced back to the legacy systems that were in use before modernization. Legacy systems may have served certain drivers and demands better in some jurisdictions than in others. For example, legacy ACH systems were traditionally interoperable with LVPS systems and, in some jurisdictions, provided a high degree of functionality (e.g., FedACH in the United States). In other jurisdictions, deficiencies in the legacy attributes created higher demands for functionality and interoperability in modernization initiatives (e.g., Denmark). The payment instrument characteristics specific to each jurisdiction also influence modernization objectives. Here, an understanding of the instruments best served by different timing, cost and functionality will also help to inform the determination of the optimal system attributes to consider.

The key lesson from the international sample is that modernization requires a holistic, multi-system approach. As the four multiple-system configurations help illustrate, the best way to achieve conflicting public policy objectives is to provide flexibility and choices in the clearing and settlement of different payment instruments, across different core systems. The particular approach taken will depend on the modernization objectives, legacy systems and jurisdictional needs but should include considerations of the cross-system interdependencies that may help or inhibit the development of distinct and complementary core systems.

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[60] Payments Canada, *International Research and Benchmarking Survey Results—Core Systems*, February 2009.
[61] Chapman et al. 2015.
[62] SPEI was designed as an RTGS with LSM and a high capacity for low-value retail direct credits. The FPS is an ERPS and uses DNS to make most funds available several hours after initiation.

Taking a multi-system perspective that considers all of the jurisdictional factors will help Canada to develop a holistic plan for each of its core payment systems. Such a plan would look to optimize each core system with the most appropriate attributes and features, so that each works together to ensure that the overall system meets modernization objectives. In planning across each of its core systems simultaneously, Canada could form a blueprint that would best deliver on each of its public policy objectives and address as many drivers, needs and gaps as possible, while maximizing the potential for the overall payment system to serve participants and end-users.

Appendix I: Systems Overview of Each Jurisdiction Scanned

Jurisdiction	Primary batch clearing system type	Primary LVPS type	ERPS (or build started)	Additional core systems
Argentina	ACH	RTGS with LSM	No	
Australia	Decentralized batch	RTGS with LSM	✓	
Brazil	Decentralized batch	RTGS with LSM	✓	
Canada	Decentralized batch	RTGS equivalent	No	
Chile	ACH	RTGS with LSM	✓	LVPS—RTGS equivalent
China	ACH	RTGS with LSM	✓	
Denmark	Decentralized batch	RTGS with LSM	✓	SBE intraday settlement system
Egypt	ACH	RTGS with LSM	No	
Europe	Pan-European SBE (2) and ACH	RTGS with LSM	✓ (in build)	LVPS—RTGS equivalent
India	ACH	RTGS with LSM	✓	
Ireland	SBE	RTGS with LSM	No	
Israel	ACH	RTGS with LSM	No	
Japan	ACH (Zengin)	RTGS with LSM	✓(Zengin)	
Mexico	ACH	RTGS with a high capacity for retail transactions		
Netherlands	ACH	RTGS with LSM	✓	
New Zealand	SBE	RTGS with LSM	No	
Poland	SBE	RTGS with LSM	✓	
Qatar	ACH	RTGS with LSM	No	
Russia	SBE	RTGS with LSM	No	
Saudi Arabia	ACH	RTGS with LSM	✓	
Singapore	SBE	RTGS with LSM	✓	
South Africa	ACH	Basic RTGS	✓	
South Korea	ACH	RTGS with LSM	✓	
Sweden	SBE	RTGS with LSM	✓	
Switzerland	ACH (PostFinance similar to ACH)	RTGS with a high capacity for retail transactions		
Turkey	ACH	RTGS with a high capacity for retail transactions		
United Kingdom	ACH	RTGS with LSM	✓	
United States	ACH	Basic RTGS	✓ (in build)	ACH (EPN) LVPS—RTGS equivalent

Appendix II: Payments Canada's Payment Systems Overview

Canada maintains two systems as part of its core payment system infrastructure, the Automated Clearing Settlement System (ACSS) and the Large Value Transfer System (LVTS). Together, these systems provide the core of payment system clearing and settlement in Canada.

The ACSS, introduced in 1984, is the system through which a majority of payment items in Canada are cleared (about 27 million items on average per business day). The ACSS is an information system used by Canadian financial institutions to clear and reconcile many of the payments made in Canada, including debit cards, ATM transactions, direct debits and credits, and paper payments such as cheques and cheque images.[63] The ACSS is supported by a framework of rules, standards and procedures that govern the exchange, clearing and settlement of payments between financial institutions. The ACSS's main functions are that of an inter-FI payment netting and collation system, to facilitate the clearing of bilateral batch payment files exchanged by Canadian financial institutions. At the end of the daily exchange process, ACSS entries are used to determine the multilateral net positions of the system participants for settlement of the items entered into the ACSS.

The LVTS is an LVPS, introduced in 1999, to facilitate the transfer of irrevocable payments in Canadian dollars. Through the LVTS, interbank and customer transactions are made between participating financial institutions virtually instantaneously, and the money can be credited to the recipient's account on a timely basis. On average, the LVTS is used to clear and settle about $150 billion in Canadian-dollar payments each business day, or approximately 90 per cent of the total value moving through the Canadian payment system. The LVTS is particularly suitable for time-sensitive payments and is used for important Canadian payments and financial system settlement transactions.

The LVTS offers participants a process that provides real-time payment finality. Each payment is final and irrevocable, and settlement is assured immediately, even though the actual settlement occurs at the end of the day through DNS.[64]

[63] Only payments that result in an inter-FI transfer of funds use the ACSS. Since on-us payments do not involve an inter-FI transfer, they clear outside of the ACSS. Credit card and Interac e-transfers also clear outside of the ACSS.
[64] Finality assurance is provided for, in large part, by the provision of collateral sufficient to cover the largest participant's default and the Bank of Canada's guarantee to provide support in the event of multiple participants being unable to settle.

Appendix III: Definitions

Term	Description
ACH	Automated clearing house; centralized architecture that is used to clear and reconcile batches of payment items. The processing of submitted files varies greatly from region to region. Some systems only hold and forward batches upon settlement (i.e., settlement before exchange), while others will pull out individual items for validation, sorting or routing.
AML/CFT	Anti-Money Laundering/Counter Financing of Terrorism. Legal requirements by which financial institutions globally, and many non-financial institutions, are required to identify and report transactions of a suspicious nature to the financial intelligence unit in their respective country.
Batch retail payment systems	Systems most commonly used to clear and reconcile direct credit and direct debit payments. Batch refers to the transmission or processing of a group of payment orders and instructions as a set at discrete intervals of time.
Clearing	The process of transmitting, reconciling and, in some cases, confirming payment orders or security transfer instructions prior to settlement, possibly including the netting of instructions and the establishment of final positions for settlement.
Core payment system	A core payment system is defined as one that (i) includes at least clearing and settlement, where settlement occurs in central bank funds, and (ii) is central to the efficiency and stability of the financial system and economy.
Decentralized batch retail systems	Payment systems characterized by bilateral exchanges made outside of a central system and the separate entry of batch totals into a separate clearing system.
Direct participant	A payment services provider that accesses core payment systems directly through membership of a financial payment system operator (without sponsorship or agency agreement with other bank/payment service providers).
DNS system	Deferred net settlement system. A system that effects the settlement of obligations or transfers between or among counterparties on a net basis at some later time.
Efficiency	Refers to how effectively the processes are carried out to meet end-users' needs and an efficient allocation of resources.
End-user	Those who use, or are likely to use, services provided by payment systems.
ERPS	Expedited retail payment systems are retail payment systems that are integrated into core payment systems that have direct central bank involvement (in clearing or settlement processes) and are designed with a purpose to exchange, clear and provide funds access to payees in a timely basis.
FI	Financial institution.
FPS	Faster Payments system, the ERPS established in the United Kingdom.
Indirect participant	A payment services provider that accesses the payment system though an agency agreement (i.e., sponsorship) with a direct participant.
Liquidity-savings mechanisms (LSM)	Queuing arrangements in a payment system, where queued payments are released as part of a bilateral or multilateral offsetting of payments. The use of the queue and offsetting reduces the liquidity required to meet the controls to enable the transactions to be sent to other participants.
LVPS	Large-value payment systems.
Multi-use core system	Core payment systems that serve both LVPS and retail payment system functions.
Payment service provider	An entity that provides payment services to enable the transfer of funds (e.g., a bank providing payment services for a customer). It includes non-banks and other service providers that use the payment systems to provide payment services to consumers or service users.

Payment system operator	An entity responsible for managing and operating a payment system.
PFMI	Principles for Financial Market Infrastructures.
Posting	The process of making funds available at an account, without restrictions for their immediate withdrawal.
PPO	Public policy objectives
PSD	Payment services directive issued by the European Commission.
Real-time payments (near real time)	In this report, we use the term to describe clearing and settlement processes that take place in under a minute. Near real time is used to describe processes that take place in under three minutes (but longer than one minute). For example, an **ERPS** is described as being "real time," if payment funds are available to recipients in one minute or less from the time of payment initiation.
Retail payments	Retail payments are mainly consumer payments of relatively low value and urgency.
(Basic) RTGS	In real-time gross settlement systems, each payment is settled individually as soon as the transfer order is submitted and accepted for settlement.
RTGS equivalent	A settlement system that couples final and irrevocable transactions with a DNS process to emulate an RTGS experience for users, as a DNS system settlement is delayed to allow for netting of transactions across participants.
RTGS with LSM	An RTGS system that utilizes a central queue to rapidly offset transactions between participants to lower the collateral required to settle each transaction relative to what would be needed if each transaction were settled in real time.
SEPA	Single Euro Payments Area (SEPA) is a payment-integration initiative of the European Union for simplification of bank transfers denominated in the euro.
Settlement	An act that discharges obligations in respect of funds or securities transfers between two or more parties.
Settlement before exchange (SBE) systems	Settlement before exchange systems use arrangements where participants must settle file batch totals before the files themselves may be exchanged.
Settlement system	Some jurisdictions maintain separate systems for financial participants to move transactions, funds, and collateral into and out of central bank settlement accounts. These systems can share infrastructure with the LVPS, but have separate rules and processes (e.g., a basic RTGS process for settlement transactions without queues).
STP	Straight-through processing.
Tiering	An arrangement in payment systems whereby participants in one category require the services of participants in another category to exchange and/or settle transactions on their behalf.

Sources:

- Chapman, J., J. Chiu, S. Jafri and H. Perez Saiz. 2015. "Public Policy Objectives and the Next Generation of CPA Systems: An Analytical Framework." Bank of Canada Staff Discussion Paper 2015-6; Payments Canada Discussion Paper No. 2 – September 2015.
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