Ripple Labs Inc. ("Ripple") welcomes the opportunity to comment on the Bank of England's and HM Treasury's ("HMT's") Consultation on a Digital Pound (the "Consultation"). Ripple would like to thank both institutions for the in-depth and comprehensive analysis that has been undertaken in drafting the Consultation, as well as the opportunity to provide our comments. Ripple fully supports the exploration of a Digital Pound and the benefit it may bring to the UK economy, and we appreciate the chance to share our thoughts and expertise on the matter. We would welcome the opportunity for further engagement with HMT and the Bank of England on the Consultation, and any other related consultations as may be appropriate.

<u>Interoperability is key</u>

Ripple believes that enabling a Digital Pound will allow UK authorities to support citizens and the Bank of England to fulfill its mandates by providing a platform for the next wave of financial inclusion and innovation. We see the potential benefits of a Digital Pound both at the micro- and macro-economic levels as well as through developing more efficient payments systems.

A Digital Pound can support fiscal micro-policy options, such as efficient stimulus payment delivery and targeted support for public policy objectives, such as helping families in need, the disabled, or persons of low income. While at the macro level, a Central Bank Digital Currency ("CBDC") could be used to foster the development of specific regions or sectors such as farming, green energy or AI technology. At the level of the financial system, a Digital Pound would help the Bank of England ensure continued access to risk-free public money in the digital economy and could act as a platform for future innovation by the private sector, thus building on one of the UK's great international success stories with its Fintech sector.

For a Digital Pound to fulfill its potential for people and businesses, it will need to coexist and interact with other payment schemes both domestically and internationally. Without seamless domestic interoperability and cross-border functionality, a Digital Pound will significantly underachieve its potential. Ripple considers interoperability through three core aspects:

1. <u>Technology</u>: Central Banks, such as the Bank of England, will need the ability to actually exchange assets between ledgers, rather than issuing instructions via an API. The key will be for all Central Banks to enable cross-issuance of CBDCs on interoperable ledgers. Just as the global internet thrived by early agreement on common protocols like IP and HTTP, so too do Central Banks need to start coordinating on CBDC standards to cover basic functions, including transaction-level operations, such as escrow and hash time-locks, identity and addressing schemes, and Flexible routing to determine the most efficient ways of transmission. We address these aspects further in our reply to the Technology Working Paper below.

2. <u>Payments</u>: A Digital Pound will need its own rules and policies to best fit UK public policy objectives. But it will also need to be guided by collective protocols that will enable it to cooperate seamlessly with other Digital Currencies and existing payments methods. There is no benefit to creating a Digital Pound which offers end-users an experience that has more friction than a traditional payment: it just will not be used.

3. <u>Cross Border</u>: For a Digital Pound to have maximum utility for people and businesses, it will need the ability to support global transactions. Without seamless cross-border functionality, a Digital Pound will risk acting like a 'walled-garden' for UK financial activities and potentially reduce UK openness to global financial activity, rather than support it. To enable a truly efficient global market, a bridge should be specifically optimised for payments and support the same speed, scalability, low cost and security that the Digital Pound will provide domestically. This bridge could be a currency, technology or both and could be efficiently provided by the private sector, as in traditional FX markets, rather than requiring significant and laborious cross-border and international institutional coordination and development.

One fundamental question for a Digital Pound, beyond its technical design, is that of privacy. Ripple supports the Consultation's proposal to limit access to private, consumer data by the public sector on grounds of privacy and individuals' rights. We support the intermediated approach that will allow the private sector to viably promote the cybersecurity of the Digital Pound ecosystem while offering consumers uses of the Digital Pound that are most appropriate for them. This approach will balance privacy, security and utility and so should best promote the uptake of the Digital Pound.

<u>Proceeding with a Digital Pound</u>

In summary, Ripple believes the public policy benefit of a Digital Pound is clear: to provide public money in a digital economy, to build a public sector-managed and commercially-neutral platform for financial innovation, and to defend the UK's monetary sovereignty against the potential of a dominant, usurping international Bigtech currency or the creeping use of another digitalised fiat currency in the UK.

The challenge remains in finding compelling retail use-cases that will make citizens and consumers want to use a Digital Pound should one be developed. This will necessarily require close cooperation between the public and private sectors: something which Ripple welcomes warmly. The unforeseen but very welcome development of Open Banking products and companies in the UK following the introduction of the EU Payments Services Directive 2 makes us confident that something similar will happen following the development of a Digital Pound.

Ripple is aware of how much work the Bank of England and HMT have already put into exploring a Digital Pound and would urge the UK authorities to proceed with its development. We are excited about this opportunity for the UK to drive forward its excellence in financial innovation and Fintech, and to enhance its ability to provide a safe and effective form of public money for a digital age.

Below we introduce Ripple and our work to date on CBDC development globally, and respectfully submit our responses to specific questions of both the overall consultation (Appendix A) and the Technology Working Paper (Appendix B). We would, of course, be happy to provide any further information you might require, or to discuss any aspect of this response in more depth.

<u>About Ripple</u>

Using blockchain technology, Ripple allows financial institutions to process payments instantly, reliably, cost-effectively, and with end-to-end visibility anywhere in the world. Our customers are financial institutions that want tools to effect faster and less costly cross-border payments, as well as eliminate the uncertainty and risk historically involved in moving money across borders using interbank messaging alone.

Some customers, in addition to deploying Ripple's blockchain solution RippleNet, leverage the digital asset known as XRP for an On-Demand Liquidity ("ODL") capability. Just as Bitcoin is the native asset to the open-source Bitcoin ledger, and Ethereum is the native asset to the open-source Ethereum ledger, XRP is the native asset to the

open-source XRP Ledger. XRP, given its unique design, can serve as a near instantaneous bridge between fiat currencies (or any two representations of value), further reducing the friction and costs for commercial financial institutions to transact across multiple global markets.

Although Ripple utilizes XRP and the XRP Ledger in its product offerings, XRP is independent of Ripple. The XRP Ledger is decentralized, open-source, and operates on what is known as a "consensus" protocol. While there are well over a hundred known use cases for XRP and the XRP Ledger, Ripple leverages XRP for use in its product suite because of XRP's suitability for cross-border payments. Key characteristics of XRP include speed, scalability, energy efficiency, and cost efficiency - all of which benefits the consumer and helps reduce friction in the market for cross-border payments.

Building on the utility of XRPL technology, Ripple has a CBDC team which works with Central Banks worldwide to support their investigation, trial, and implementation of CBDCs. We have officially announced four CBDC projects in concert with Central Banks so far and we have a number more under NDA:

- We are supporting the **Royal Monetary Authority of Bhutan** as it looks to drive more innovation and digitisation in the country via the introduction of a CBDC.
- We are helping the Republic of Palau develop their own national digital token. **Palau** uses the US Dollar so we are working with them to create a government-issued stablecoin. It will be issued by the government and collateralized by dollars held in a US bank.
- We have recently announced a cooperation agreement with the **Central Bank of Montenegro**, which aims to develop a strategy and pilot programme to launch the country's first digital currency in the form of a CBDC or national stablecoin, given that Montenegro uses the Euro. Aligning with the Central Bank's core objectives, the digital currency's introduction is another step forward to digitising financial services and fostering a world of greater financial accessibility for Montenegro's citizens.
- Ripple has been selected to showcase a real estate asset tokenisation solution as part of the **Hong Kong Monetary Authority's (HKMA)** inaugural 'e-HKD Pilot Programme'. e-HKD Pilot Programme will see a series of pilots conducted with various industry players to gain in-depth research into application, implementation, and design issues related to the e-HKD. As a leading provider of real world asset tokenisation capabilities, Ripple will demonstrate their use case under e-HKD Pilot Programme, with a focus on real estate asset tokenization and equity release leveraging the e-HKD.

Appendix A

Digital Pound Consultation questions

1. ***Do you have comments on how trends in payments may evolve and the opportunities and risks that they may entail?***

The development of cryptoassets that can be used for domestic payments and cross-border flows, via a blockchain, is the latest stage of payments digitisation. Digital, blockchain-based payments can offer near instant transactions with a high degree of transparency. These payments can often be based on more sustainable technology than traditional payments. Jurisdictions around the world have recognised the benefits of private innovation around blockchain-based payments and are regulating the space to build trust for consumers and certainty for businesses.

It is natural that public institutions should look to digitise public money in a similar way to private money. The benefits of speed, efficiency and transparency that private digital money offers consumers can be replicated by the public sector for their own objectives and for the benefit of their citizens, especially citizens that are currently underserved or not participants in the traditional finance ecosystem. Central Banks issuing their own digital currencies would be a natural evolution of how we exchange value.

In many ways a CBDC would i be a direct improvement over traditional public money. Existing fiat currencies were created in a much less globalised world and are not designed for efficient cross-border exchange. CBDCs offer the protections afforded to fiat currencies, bound by the regulation or laws of each country, but with the benefits of digitisation. As has happened in other industries, beneficial technological innovation tends to win out over time, so we should expect to see digital payments come to make up the large majority of all payments in the future, via both private and public money.

CBDCs offer a number of positive opportunities for governments and their citizens:

- **Financial inclusion**: Increasing access to financial services for under and unbanked populations and enhance direct person-to-person payments, by facilitating much lower-cost services than can be provided by traditional brick and mortar institutions.
- **Enhancing payment infrastructure**: Increasing the speed and efficiency of payments, while reducing costs and failure rates.
- **Fostering innovation**: Using advanced digital features like smart contracts and programmable money that will be the basis of new financial services.

- **Maintaining sovereignty**: Ensuring Central Banks retain sovereignty over monetary policy and not allowing alternative currencies to dominate the market
- **Reducing energy use & environmental resources** by phasing out the printing of paper money and minting of coins.
- **Transparency enhancement** for government spending and the use of public money.

Two sectoral risks potentially arise from the development of digital public money: the much discussed risk of the disintermediation of the banking sector; and the crowding out of private money.[1] Ultimately such risky outcomes can be avoided with a properly designed CBDC.

The Consultation has already taken a stance on this by affirming the proposal to design and create a retail Digital Pound with limits on consumer holdings. These limits make sense as a temporary measure to ensure the smooth introduction of the new type of money.[2] It is less clear that a CBDC, in any jurisdiction, will be so compelling as to require a permanent limit to stop disintermediation.

Ripple welcomes a Digital Pound as part of the mix of future money in the UK and beyond: digital, physical, public, and private. Each has different characteristics, benefits and limitations. Given this we do not think it likely that one form of money will close out all the others. The important element will be seamless interoperability between them. Currently this already exists for converting cash to bank deposits, for example; or for turning a bank deposit into e-money. The future evolution of payments will require equally seamless conversion of cash and bank deposits into private and public digital money: cryptocurrencies and CBDC.

2. ***Do you have comments on our proposition for the roles and responsibilities of private sector digital wallets as set out in the platform model? Do you agree that private sector digital wallet providers should not hold end users' funds directly on their balance sheets?***

We agree that the platform model of a CBDC is the most appropriate. This will balance out operational requirements between the public and private sector. By providing a public infrastructure on which private sector firms can innovate, the Bank of England

---

[1] There is evidence that public money (backed by the state) has a tendency to dominate private money as a means of exchange, as shown for example through the eventual dominance of Bank of England notes in the 19th century and in coin mintage in early medieval France. There is no *a priori* reason to expect a different dynamic with a digital currency, if future digital forms of money are identical in their underlying characteristics.

[2] As there were, for example, during the introduction of faster payments and contactless payments.

can spur innovation in a way that boosts competition (by reducing technological infrastructure lock-in by one provider) and maintains overall system safety and soundness.

It is right that the digital wallet should be the primary access point to the Digital Pound system, given it will be the consumer on- and off-ramp. We agree that as part of the differentiation between a digital wallet (that holds value as a Digital Pound) and a bank app (that holds value as a commercial bank deposit), digital wallets should not hold customer funds directly on their balance sheets. Given that a Digital Pound is not proposed to be interest-bearing it would not make business sense for them to hold customer funds anyway. The important elements are:

- Ease of conversion from one type of money to another (interoperability)
- Consumer certainty of 1:1 convertibility with fiat and to the status of their value-holdings (public money)

Nonetheless, there is a risk that the wallet approach could limit innovation - some of the benefits of a CBDC are around programmability, and if this is limited at a wallet level this runs the risk of limiting innovation. Some examples noted in the Consultation could be achieved with traditional bank accounts today. We would recommend further investigation of use-cases and business models as part of the ecosystem development of Payment Interface Providers (PIPs) and External Service Interface Providers (ESIPs).

3. ***Do you agree that the Bank should not have access to users' personal data, but instead see anonymised transaction data and aggregated system-wide data for the running of the core ledger? What views do you have on a privacy-enhancing digital pound?***

We agree that the Bank of England should not have access to users' personal data. CBDCs, in general, should not be designed to give public institutions access to all consumer data: nor do we think a central bank would want that. Responsible design choices (e.g., employing messaging layers), coupled with appropriate analytics, can give the government the tools it needs to ensure system stability and that illicit activity does not occur. Technology can enable central banks to ensure both privacy and cybersecurity are embedded in the design of its CBDC.

Privacy is a core consideration for the implementation of CBDCs as it is with any public project involving personal or personalised information regarding citizens. The degree of privacy can reasonably vary significantly between jurisdictions, based on culture, the objectives and use-cases of a given CBDC, and the existing approach to financial privacy in the traditional financial system.

4. What are your views on the provision and utility of tiered access to the digital pound that is linked to user identity information?

This needs careful consideration as tiering could be unintentionally exclusionary, and potentially run counter to the objective of maintaining the Bank of England's control over the supply of public money.

5. What views do you have on the embedding of privacy-enhancing techniques to give users more control of the level of privacy that they can ascribe to their personal transactions data?

We support any measures to give consumers more control over their privacy. The deeper these privacy-enhancing techniques are embedded in the technology the more trust it will build for consumers. Consumer trust is core to a Digital Pound being a success.

As well as personalised privacy measures, however, it will still be important that the Bank of England and other system participants can access the necessary anonymised or aggregated data to ensure the proper functioning of the Digital Pound, monitor for any illicit activity, and offer relevant consumer services.

6. Do you have comments on our proposal that in-store, online and person-to-person payments should be highest priority payments in scope? Are any other payments in scope which need further work?

If the ambition is to create a retail CBDC that is primarily used for retail payments, it makes sense to prioritise these forms of payments. The important aspect will be the ease of use by the end user. There is no point creating a system that has more friction than existing forms of in-store, online or person-to-person payments, or those payments that are currently being developed such as improvements to Open Banking. Part of this issue will be the ease of interoperability between existing payments methods, including commercial bank deposits, and future CBDC systems. Equally, it will be important to ensure support for cross-border functionality so as not to create 'walled gardens' across the globe. Indeed, direct access to a Digital Pound for overseas visitors could be one major benefit of a UK CBDC compared to traditional fiat solutions.

7. What do you consider to be the appropriate level of limits on individual's holdings in transition? Do you agree with our proposed limits within the £10,000–£20,000 range? Do you have views on the benefits and risks of a lower limit, such as £5,000?

This question is not of direct relevance to Ripple's business and expertise so we have no specific comment. However we would note that if the ambition is to have widespread adoption of a Digital Pound and to foster innovation in this space by the private sector, then a higher limit would seem to offer greater possibilities.

8. ***Considering our proposal for limits on individual holdings, what views do you have on how corporates' use of digital pounds should be managed in transition? Should all corporates be able to hold digital pounds, or should some corporates be restricted?***

All corporates should be able to hold a Digital Pound. The proposed aim is to create a digital form of public money. Discriminating between different types of corporates (or even, theoretically in the future, different types of individuals) would undermine that ambition and lead to a fracturing of the provision of public money in the UK. This would undermine confidence in the validity of money in the UK more widely and, at the very least, lead to consumer confusion and payments inefficiency: the very thing the development of a Digital Pound is designed to tackle. AML/CTF and KYC/KYB are vital, and well-understood, elements of the payments landscape today, and should be an important part of a future Digital Pound system.

9. ***Do you have comments on our proposal that non-UK residents should have access to the digital pound, on the same basis as UK residents?***

Cross-border interoperability will be an important end-state for a Digital Pound (and CBDCs more widely). Allowing non-UK residents access to the Digital Pound would effectively recreate the situation that we currently have, of allowing international residents to hold fiat Sterling. There is no up-front reason to presume that, for purposes of transactions inside the UK, a non-UK resident should not be able to access a Digital Pound. And indeed allowing this access will likely facilitate cross-border trade and inward tourism.

10. ***Given our primary motivations, does our proposed design for the digital pound meet its objectives?***

The current proposals seem to be best practice for designing a retail Digital Pound. This should achieve the outcomes of maintaining the provision of public money in a digital economy, while supporting innovation and choice.

As expressed in our opening remarks, Ripple considers that for a Digital Pound to fulfill its potential for people and businesses in the UK, it will need to coexist and interact with

other payment systems both domestically and internationally. Without seamless domestic interoperability and cross-border functionality, a Digital Pound will significantly underachieve its potential.

11. **Which design choices should we consider in order to support financial inclusion?**

It is important to stress the need for equal access to a Digital Pound, both across society and within the economy. An important part of this will be the Government's continuing support and promotion of digital inclusion. Put bluntly, a Digital Pound can support *financial* inclusion, but relies upon digital inclusion. Offline capability will be an aspect that improves financial inclusion for those who are not as digitally enabled, or for locations without permanent access to the internet. Part of this could be ensuring that the design for a Digital Pound does not presuppose use of a mobile phone for end-user access or topping up, but could be done, for example, via the Post Office and an offline card. Interoperability would imply the ability to directly transfer cash to a Digital Pound without necessarily having to be intermediated by a bank and bank deposit.

12. **The Bank and HM Treasury will have due regard to the public sector equality duty, including considering the impact of proposals for the design of the digital pound on those who share protected characteristics, as provided by the Equality Act 2010. Please indicate if you believe any of the proposals in this Consultation Paper are likely to impact persons who share such protected characteristics and, if so, please explain which groups of persons, what the impact on such groups might be and if you have any views on how impact could be mitigated.**

Ripple has no comment on this question.

Appendix B

<u>**Technology Working Paper**</u>

<u>**Discussion questions:**</u>

Design
Based on the policy objectives outlined in the digital pound CP, the Bank assesses that privacy, security, resilience, performance, extensibility and energy usage are foundational technology considerations for CBDC (Section 3).

1. **Do you agree that these six considerations are foundational technology considerations for CBDC? Are there additional or alternative technology considerations that the Bank should be focused on? (Section 3)**

We agree in principle with the six considerations presented in the technical whitepaper as foundational technology considerations, however we would also add interoperability to the technology considerations the Bank should be focused on. This is currently identified as a functional consideration in the Technology Working Paper, however different technologies will enable different capabilities and scale with respect to interoperability, both with existing traditional systems as well as other future tokenised systems. In particular we think it is important to consider the technology's ability to support interoperability with other tokenised systems to eliminate risk and friction in business transactions that require reach and use across multiple systems, which is a critical consideration to ensure the future utility of a CBDC.

2. **Which privacy-enhancing technologies, or other privacy mechanisms, might support the proposed policy objectives, and how might they be used? (Section 3.1)**

The baseline privacy-enhancing technology which should be applied to any technology implementation is data minimisation. Practical and consistent application of data minimisation will be effective in meeting and supporting the majority of the stated policy objectives and requirements. Personal data collected during user on-boarding and payment transactions should both be limited to the information required for these purposes and remain under the control of the specific PIP and/or ESIP - in particular this data should not need to be recorded in the ledger. The collection and management of this data would be controlled through regulation of the PIPs/ESIPs, and the ledger and

broader CBDC platform would only contain pseudo-anonymous transactional and aggregate data, controlled by the central bank.

Ripple has previously created a proof-of-concept private CBDC ledger in which granular user and transaction data can be used to enhance audit, oversight and supervision whilst protecting consumers' sensitive data and privacy. This capability was based on the use of existing policy, regulatory rulesets and operational processes together with derived data published to the CBDC ledger which reveals no personal information itself. It included integration with and effective use of sovereign (or self-sovereign) identity services to ensure minimum identification requirements are met for onboarding onto the primary CBDC infrastructure, whilst not revealing any of the identity information. We welcome the opportunity to liaise further with the Bank of England on these topics and capabilities in the future.

The application of privacy-enhancing technologies beyond data minimisation will depend on the privacy requirements with respect to pseudo-anonymous and aggregate CBDC data. Access to this data will be controlled by the central bank based on privacy requirements, and greatly reduces the need for further Privacy Enhancing Technologies (PETs) to be applied. The application of more extreme transactional methods such as blind proofs / zero knowledge proofs will have a significant impact on the complexity of the system as well as the non-functional capabilities - this should be limited to cases in which the privacy requirement is strongly validated as necessary, however we feel the drawbacks and risks far outweigh the benefits and need for these approaches.

3. **Are the provisional requirements and metrics discussed in the paper, particularly for uptime, transaction throughput and transaction speed, realistic and appropriate? (Sections 3.3 and 3.4)**

The requirements are realistic but not required for all levels and functions of the system. A core DLT ledger might sacrifice speed and TPS for features such as transparency and immutability, while using traditional technologies for high throughput transaction needs. Horizontal scalability (i.e. separate ledgers) could be used to solve TPS and scalability issues long-term.

Illustrative model
The illustrative conceptual model features the core ledger, API layer, alias service and analytics as part of the Bank-managed infrastructure, while programmability and devices are featured as aspects of the CBDC ecosystem infrastructure. It also considers offline payments and interoperability with other forms of money (Section 4).

4. **Are there other significant components or activities that the Bank should consider in designing a CBDC? (Section 4)**

With the desire to move programmability to the PIPs and ESIPs, our expectation is that a bridge component would be needed between a smart contract and any Bank of England API layer. Traditionally smart contracts cannot call APIs themselves and as such would require a bridge component to help with facilitating this.

5. **Are there alternative models that might better address the technology considerations and technical requirements outlined in this paper? (Section 4)**

Yes, we feel there are alternative models which provide a broader platform for innovation and that offer more for end-users and central banks than is proposed in this paper. We feel the current proposal is not maximising the opportunity presented by technologies such as Distributed Ledger Technology and runs the risk of creating an alternative paypal like service. For a CBDC to be successful it has to provide something more than is possible with today's systems to truly be adopted.

The underlying technology being used by cryptocurrencies can be harnessed to create new financial infrastructure that can help future-proof the technology used for value transfer, and open up new opportunities beyond just the exchanging of a Digital Pound. The proposed model makes the Bank of England the gatekeeper to any innovation applied to the Digital Pound, and while this might be desired from a policy perspective, it puts a huge cost of ownership onto the Bank. There are alternative methods of directing innovation that would promote broader innovation while maintaining control. One such example is the amendment process that is leveraged by the Ripple CBDC ledger. This allows changes to be created and proposed to the ledger by 3rd parties but ultimately a change does not become active until it has been verified by the operators of the ledger. This could be highly beneficial when combined with a sandbox and would ensure future-proofing of any new infrastructure.

There is also a resiliency component that distributed ledger technology brings that single centralised services are not able to, such as removing single points of failure. Removing single points of failure is fundamental especially when engaging in a direct cash replacement that is highly decentralised / distributed and not reliant on a single party to approve peer to peer transactions.

6. **Other than those described in this paper, are there additional important factors to consider related to ledger design? (Section 4.1)**

The use of Proof of Association (PoA) consensus DLT solutions is an important factor to consider related to the investigation of DLT for core ledger design. PoA DLT solutions allow only authorised institutions the ability to validate transactions on the network, giving the central bank a mechanism of control, facilitating fast transaction close times, and are environmentally sustainable.

More widely, a DLT solution at the core ledger level would future-proof the CBDC and add security and resiliency to the system. DLT systems work in public trustless environments securing billions of pounds in value when allowing anyone access to the ledger. The central bank can take this technology and combine it with traditional solutions to provide both the advantages of DLT, such as allowing a lower level of trust to access, and address the concerns such as scale and central bank control mechanisms. As DLT solutions mature the traditional system can be reevaluated. For example the Bank might issue currency on a DLT core ledger but record movement of funds, beyond internal issuance and distribution, to a traditional distributed database solution.

DLT solutions also have the added advantage of considering security and resilience within the software protocol rather than relying on additional infrastructure as traditional systems do. This allows for more parties to participate in the system with reduced risk of fraud or outages.

7. **What are the most appropriate approaches or technologies for collecting and analysing aggregate transaction data? (Section 4.2)**

The Ripple CBDC Platform is based on XRP Ledger technology, which has a platform architecture that includes separate infrastructure for data collection, analysis and reporting purposes. This approach is effective in both maximising the efficiency of the primary ledger infrastructure as well as providing real-time insights into aggregate, event-based and summarised data from the platform. As per our response for item #2 (Appendix B - Technology Working Paper), the platform generally takes a data minimisation approach and personalised information is not held on the primary ledger or the data analysis and reporting component.

The approach of an engineered data pipeline collecting data from both the core ledger and API layer could be implemented as an extension to the base data collection, analysis and reporting approach described above.

8. **Do you agree with the need for aliases (both well-known and disposable)? If so, should the alias service be hosted as part of the Bank-managed infrastructure, or should it be distributed across the CBDC ecosystem? (Section 4.3)**

Yes, aliases will almost certainly be required in order to make any underlying system user-friendly and accessible. As part of any considerations for interoperability these aliases should be permissible on other systems to ensure the CBDC can fully interact with other payment systems.

The use of both well-known and disposable aliases makes sense and would allow one time aliases to be used, much in the same way some services now offer unique email addresses for particular sites / services. Consideration for the use of these disposable aliases should be given if facilities such as recurring payments are possible and how these would work, if at all, with disposable aliases.

As part of the CBDC infrastructure design there does need to be a method of resolving these aliases to the underlying account, whether this is a centralised service or a distributed service in delivery, there will need to be a lookup facility. To be most effective, this lookup facility should be part of the underlying infrastructure to ensure a consistent user experience and one that is not limited by the weakest wallet operator.

9. **What features would a CBDC API require to enable innovative use cases? (Section 4.4)**

One feature that would enhance the interoperability with DLT solutions is the ability to provide cryptographic proof of a transaction occurring. This feature would allow for a proof of transaction to be supplied as a response to a GET request. This cryptographic proof could be consumed by another online solution but also an offline solution such as a soda vending machine. The vending machine can then scan this proof (for example a QR code) verifying the online payment and dispensing the soda. Cryptographic proofs are critical to interoperability across DLT solutions.

10. **Do you agree with the suggested list of devices for making payments with CBDC? (Section 4.5)**

Yes, the list provided is certainly a good baseline. We would also suggest that other means of interacting with the CBDC wallets are also possible. These methods could include an SMS based wallet model where parties can message each other in the same way that mPesa or messaging services such as WhatsApp etc. can support. We have also seen alternatives where the user does not require a physical device and is simply onboarded with a very low cost card containing information such as a QR code for accessing their account. A low cost card when coupled with a PIN can be used in many more locales than digital payments alone, and thus enables solutions to scale, in addition to scaling inclusivity. These methods could be used as a very low cost method of distributing CBDC initially.

11. **How viable is it to enable interoperability between CBDC and other forms of money using existing payments infrastructure? (Section 4.6)**

Interoperability will be one of the critical elements of any CBDC. If a CBDC is not able to interoperate with other payment infrastructures it will create a walled garden and likely limit the adoption and impact of the digital currency. Earlier in the discussion and our response to question #8, the use of aliases is proposed, and while this is essential to make a CBDC usable, some 'connective tissue' is likely to be needed to interoperate with systems such as Bacs and Faster Payments so intermediaries can understand how to fund a CBDC wallet and vice versa when wanting to send money to a traditional bank account.

12. **Is programmability and smart contract functionality an important feature of a CBDC system? If so, what is the best approach to enabling such functionality? (Section 4.7)**

Programmability is an important feature of a CBDC system. While smart contracts are on the forefront of innovation they also have severe limitations, such as the need for centralised services to make API calls and the inability to automatically execute transactions. In order to reduce risk and provide a controlled stable environment the central bank can provide programmability as a set of native functions exposed by an API. For example, rather than having multiple smart contracts deployed by different parties that all escrow funds, a native "escrow" function can be added to a DLT based core ledger and exposed via an API for standardised use.

13. **How important is offline functionality in a CBDC system? What are the most effective ways to implement offline capability? (Section 4.8)**

Offline functionality is hugely important, as without this there is significant risk of exclusion. If a CBDC system is reliant on a permanent internet connection then this will greatly impact individuals' ability to participate. It is not uncommon even in UK city centres to be without a mobile phone signal, so there has to be consideration for those use-cases.

There are numerous approaches to implementing offline payments, the vast majority of which involve effectively ring-fencing funds for offline usage. This is essentially equivalent to withdrawing money from an ATM and loading up a balance on a device that has a secure element. This secure element is responsible for managing the double spend problem and can have limitations applied to the device. These devices could take the form of a normal credit card type form factor (as referenced in our response to question #10) , sim cards for phones or stickers that can be managed with a separate device. Alternatively they can also take the form of using software to facilitate the secure element, this does however potentially raise the cost of such facilities and create a barrier to entry.

Offline transactions can also play an important role in enabling transactions across the internet of things and devices such as vending machines where one side of the transaction might not be online.