

UBIN PHASE 2

Technical Documentation

Functional Testing

This report is documents the functional test scenarios and results from the three Ubin Phase 2 prototypes.

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1 Functional Testing

One of the key focuses of Ubin Phase 2 is to implement a LSM or gridlock resolution mechanism in a DLT. In order to verify LSM across the different workstreams, 24 functional test cases were defined across scenarios having two, three and five bank nodes as well varying starting balances and payment instruction amounts. An identical set of test data is executed across all three workstreams and the results are verified against the expected results against the LSM algorithm for each workstream.

Unit testing and functional testing was conducted through the RESTful APIs. The diagram below illustrates the test harness set up and test approach.

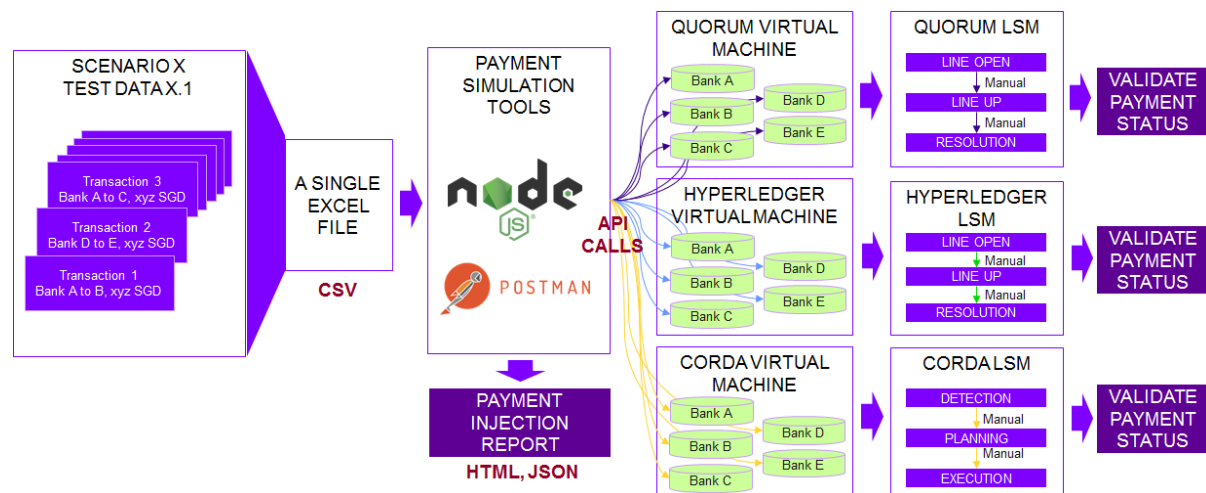
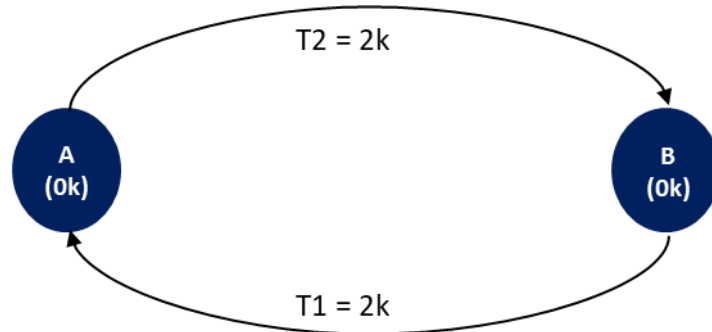


Figure 1: Test Setup and Test Approach

2 Test Scenarios and Results

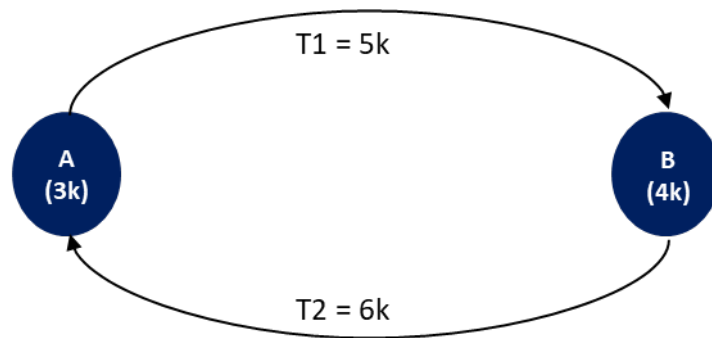
2.1 Two participants' gridlock fully resolved

2.1.1 Two obligations, starting balance is 0 for both participants



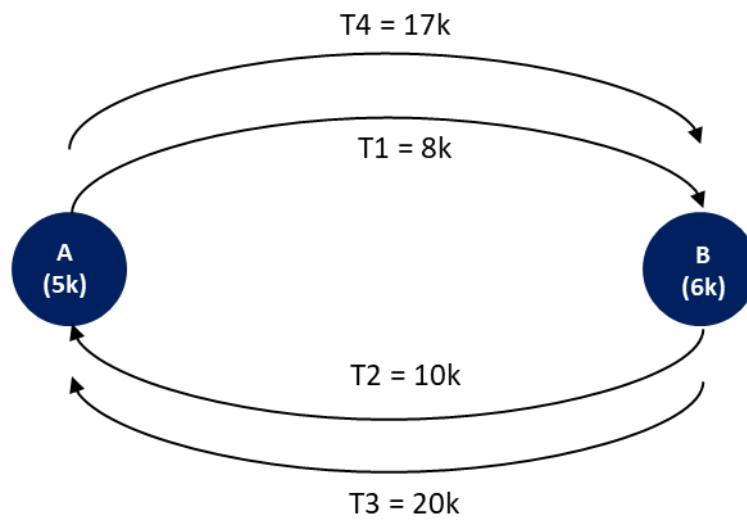
	A (\$k)	B (\$k)	Post LSM Netting Status		
Starting balance	0	0	Corda	Hyperledger Fabric	Quorum
T1	+2	-2	Settled	Settled	Settled
T2	-2	+2	Settled	Settled	Settled
			A (\$k)		B (\$k)
Starting balance			0		0
Closing balance	Corda		0		0
	Hyperledger Fabric		0		0
	Quorum		0		0

2.1.2 Two obligations



	A (\$k)	B (\$k)	Post LSM Netting Status		
Starting balance	3	4	Corda	Hyperledger Fabric	Quorum
T1	-5	+5	Settled	Settled	Settled
T2	+6	-6	Settled	Settled	Settled
			A (\$k)		B (\$k)
Starting balance			3		4
Closing balance	Corda		4		3
	Hyperledger Fabric		4		3
	Quorum		4		3

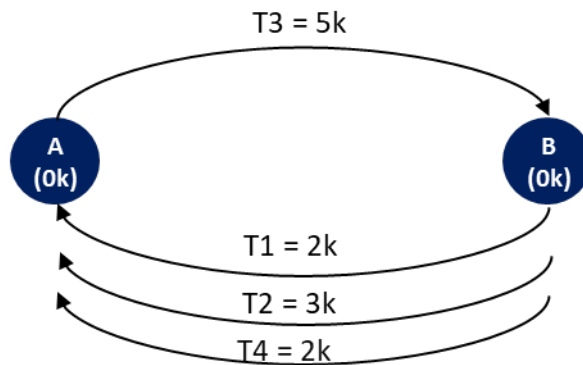
2.1.3 Four obligations



	A (\$k)	B (\$k)	Post LSM Netting Status		
Starting balance	5	6	Corda	Hyperledger Fabric	Quorum
T1	-8	+8	Settled	Settled	Settled
T2	+10	-10	Settled	Settled	Settled
T3	+20	-20	Settled	Settled	Settled
T4	-17	+17	Settled	Settled	Settled
			A (\$k)	B (\$k)	
Starting balance			5	6	
Closing balance	Corda		10	1	
	Hyperledger Fabric		10	1	
	Quorum		10	1	

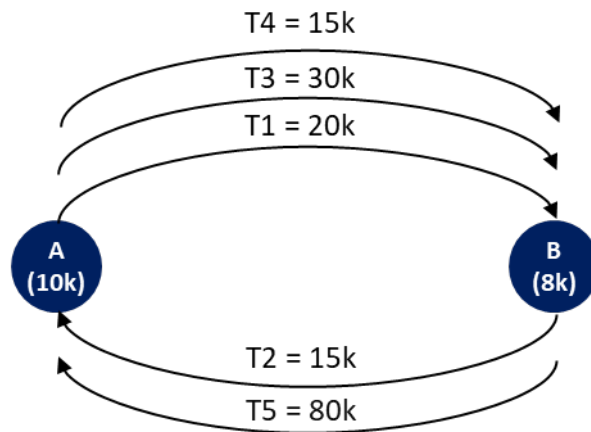
2.2 Two participants' gridlock partially resolved

2.2.1 Four total obligations, starting balance is 0 for both participants



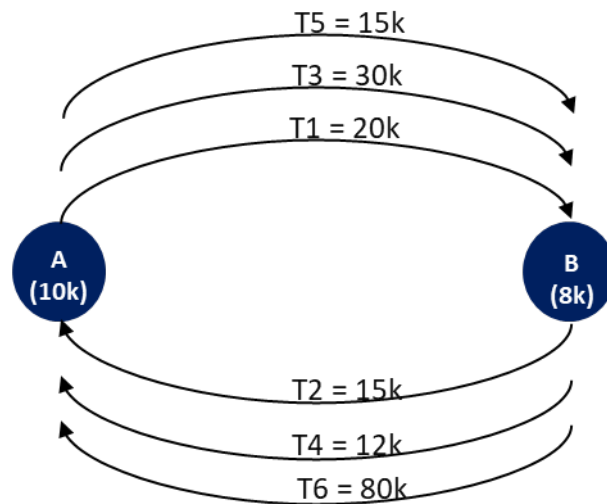
	A (\$k)	B (\$k)	Post LSM Netting Status		
Starting balance	0	0	Corda	Hyperledger Fabric	Quorum
T1	+2	-2	Settled	Settled	Settled
T2	+3	-3	Settled	Settled	Settled
T3	-5	+5	Settled	Settled	Settled
T4	+2	-2	Unsettled	Unsettled	Unsettled
			A (\$k)		B (\$k)
Starting balance			0		0
Closing balance	Corda		0		0
	Hyperledger Fabric		0		0
	Quorum		0		0

2.2.2 Five total obligations



	A (\$k)	B (\$k)	Post LSM Netting Status		
Starting balance	10	8	Corda	Hyperledger Fabric	Quorum
T1	-20	+20	Settled	Settled	Settled
T2	+15	-15	Settled	Settled	Settled
T3	-30	+30	Unsettled	Unsettled	Unsettled
T4	-15	+15	Unsettled	Unsettled	Unsettled
T5	+80	-80	Unsettled	Unsettled	Unsettled
			A (\$k)		B (\$k)
Starting balance			10		8
Closing balance	Corda		5		13
	Hyperledger Fabric		5		13
	Quorum		5		13

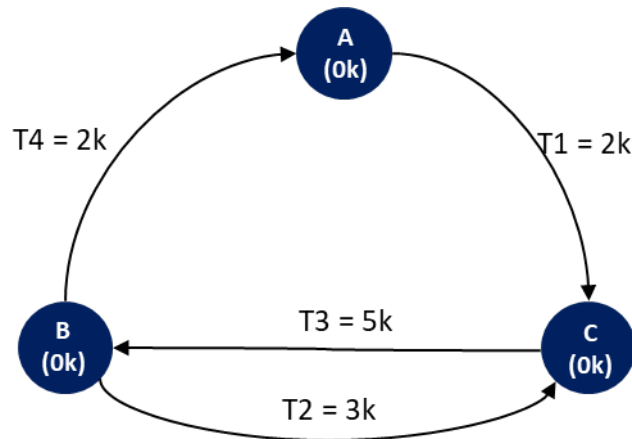
2.2.3 Six total obligations



	A (\$k)	B (\$k)	Post LSM Netting Status		
Starting balance	10	8	Corda	Hyperledger Fabric	Quorum
T1	-20	+20	Settled	Settled	Settled
T2	+15	-15	Settled	Settled	Settled
T3	-30	+30	Unsettled	Unsettled	Unsettled
T4	+12	-12	Settled	Unsettled	Settled
T5	-15	+15	Settled	Unsettled	Unsettled
T6	+80	-80	Unsettled	Unsettled	Unsettled
			A (\$k)	B (\$k)	
Starting balance			10	8	
Closing balance	Corda		2	16	
	Hyperledger Fabric		5	13	
	Quorum		17	1	

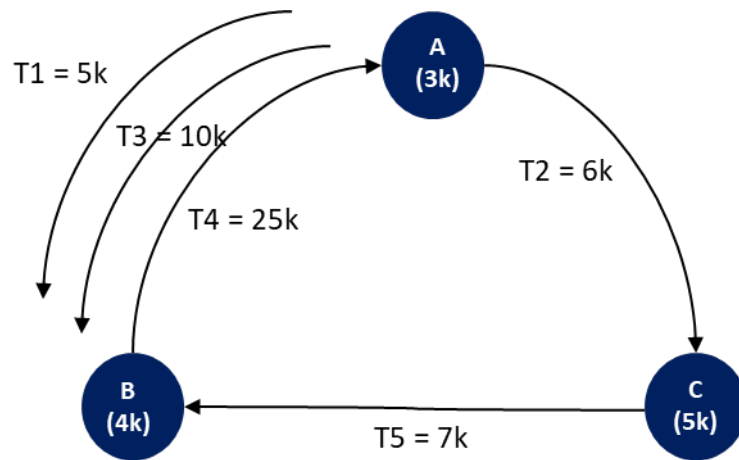
2.3 Three participants' gridlock fully resolved

2.3.1 Four obligations, starting balance is 0 for all participants



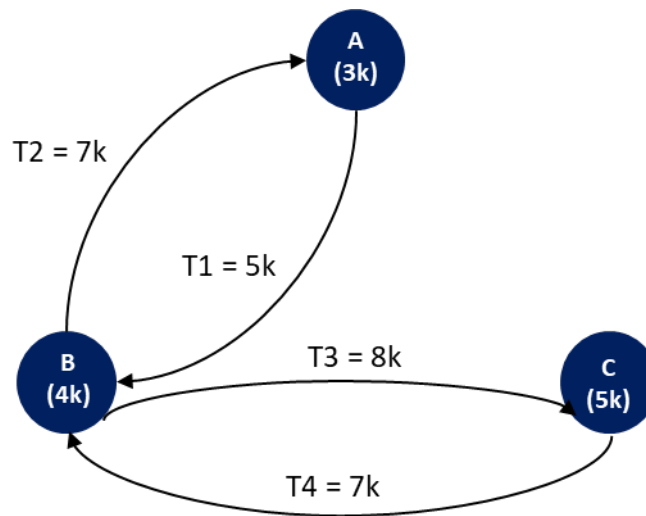
	A (\$k)	B (\$k)	C (\$k)	Post LSM Netting Status		
Starting balance	0	0	0	Corda	Hyperledger Fabric	Quorum
T1	-2		+2	Unsettled	Settled	Settled
T2		-3	+3	Unsettled	Settled	Settled
T3		+5	-5	Unsettled	Settled	Settled
T4	+2	-2		Unsettled	Settled	Settled
				A (\$k)	B (\$k)	C (\$k)
Starting balance				0	0	0
Closing balance	Corda			0	0	0
	Hyperledger Fabric			0	0	0
	Quorum			0	0	0

2.3.2 Five Obligations



	A (\$k)	B (\$k)	C (\$k)	Post LSM Netting Status		
Starting balance	3	4	5	Corda	Hyperledger Fabric	Quorum
T1	-5	+5		Unsettled	Settled	Settled
T2	-6		+6	Unsettled	Settled	Settled
T3	-10	+10		Unsettled	Settled	Settled
T4	+25	-25		Unsettled	Settled	Settled
T5		+7	-7	Unsettled	Settled	Settled
				A (\$k)	B (\$k)	C (\$k)
Starting balance				3	4	5
Closing balance	Corda			3	4	5
	Hyperledger Fabric			7	1	4
	Quorum			7	1	4

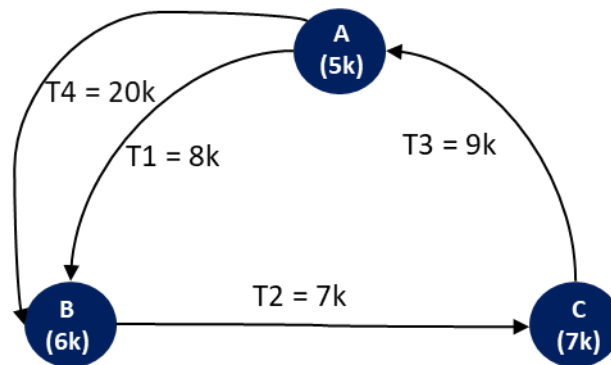
2.3.3 Four obligations, 2 cycles with one common participant



	A (\$k)	B (\$k)	C (\$k)	Post LSM Netting Status		
Starting balance	3	4	5	Corda	Hyperledg er Fabric	Quorum
T1	-5	+5		Settled	Settled	Settled
T2	+7	-7		Settled	Settled	Settled
T3		-8	+8	Settled	Settled	Settled
T4		+7	-7	Settled	Settled	Settled
				A (\$k)	B (\$k)	C (\$k)
Starting balance				3	4	5
Closing balance	Corda			5	1	6
	Hyperledger Fabric			5	1	6
	Quorum			5	1	6

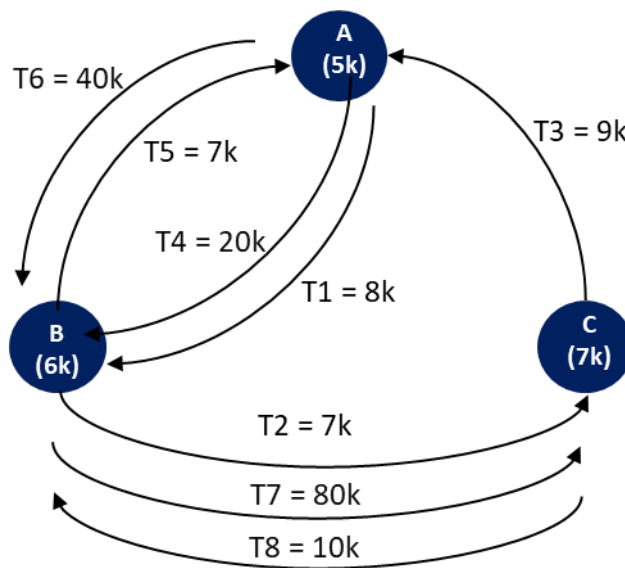
2.4 Three participants' gridlock partially resolved

2.4.1 Four Total Obligations



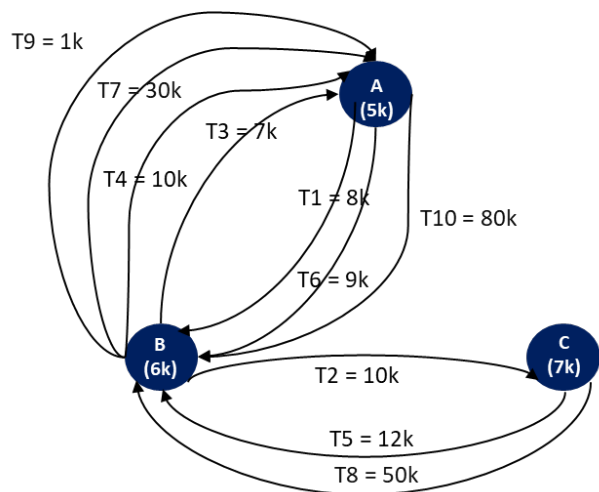
	A (\$k)	B (\$k)	C (\$k)	Post LSM Netting Status		
Starting balance	5	6	7	Corda	Hyperledger r Fabric	Quorum
T1	-8	+8		Settled	Settled	Settled
T2		-7	+7	Settled	Settled	Settled
T3	+9		-9	Settled	Settled	Settled
T4	-20	+20		Unsettled	Unsettled	Unsettled
				A (\$k)	B (\$k)	C (\$k)
Starting balance				5	6	7
Closing balance	Corda			6	7	5
	Hyperledger Fabric			6	7	5
	Quorum			6	7	5

2.4.2 Eight Obligations



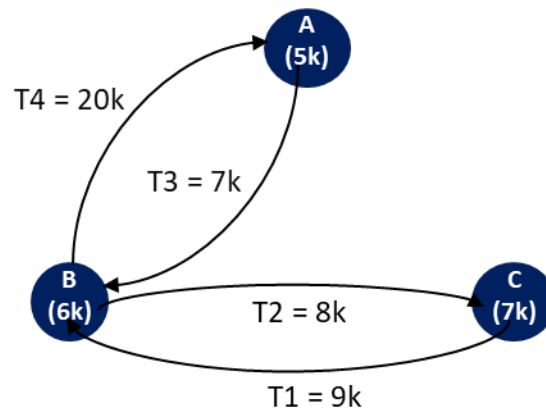
	A (\$k)	B (\$k)	C (\$k)	Post LSM Netting Status		
Starting balance	5	6	7	Corda	Hyperledger Fabric	Quorum
T1	-8	+8		Settled	Settled	Settled
T2		-7	+7	Settled	Settled	Settled
T3	+9		-9	Settled	Settled	Settled
T4	-20	+20		Unsettled	Unsettled	Unsettled
T5	+7	-7		Unsettled	Settled	Settled
T6	-40	+40		Unsettled	Unsettled	Unsettled
T7		-80	+80	Unsettled	Unsettled	Unsettled
T8		+10	-10	Unsettled	Unsettled	Unsettled
				A (\$k)	B (\$k)	C (\$k)
Starting balance				5	6	7
Closing balance	Corda			6	7	5
	Hyperledger Fabric			13	0	5
	Quorum			13	0	5

2.4.3 Ten total obligations, 2 cycles with one common participant



	A (\$k)	B (\$k)	C (\$k)	Post LSM Netting Status		
Starting balance	5	6	7	Corda	Hyperledger Fabric	Quorum
T1	-8	+8		Settled	Settled	Settled
T2		-10	+10	Settled	Settled	Settled
T3	+7	-7		Settled	Settled	Settled
T4	+10	-10		Settled	Settled	Settled
T5		+12	-12	Settled	Settled	Settled
T6	-9	+9		Settled	Settled	Settled
T7	+30	-30		Unsettled	Unsettled	Unsettled
T8		+50	-50	Unsettled	Unsettled	Unsettled
T9	+10	-10		Unsettled	Unsettled	Unsettled
T10	-80	+80		Unsettled	Unsettled	Unsettled
				A (\$k)	B (\$k)	C (\$k)
Starting balance				5	6	7
Closing balance	Corda			5	8	5
	Hyperledger Fabric			5	8	5
	Quorum			5	8	5

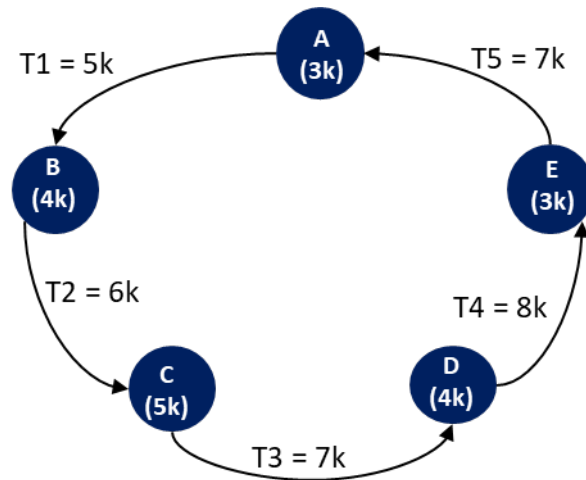
2.4.4 Four total obligations, 2 cycles with one common participant



	A (\$k)	B (\$k)	C (\$k)	Post LSM Netting Status		
Starting balance	5	6	7	Corda	Hyperledger Fabric	Quorum
T1		+9	-9	Settled	Settled	Settled
T2		-8	+8	Settled	Settled	Settled
T3	-7	+7		Unsettled	Unsettled	Unsettled
T4	+20	-20		Unsettled	Unsettled	Unsettled
				A (\$k)	B (\$k)	C (\$k)
Starting balance				5	6	7
Closing balance	Corda			5	7	6
	Hyperledger Fabric			5	7	6
	Quorum			5	7	6

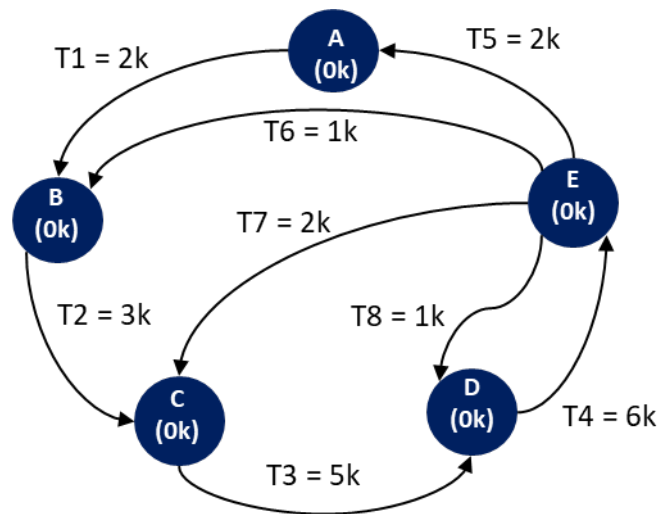
2.5 Five participants' gridlock fully resolved

2.5.1 Five Obligations of a simple cycle



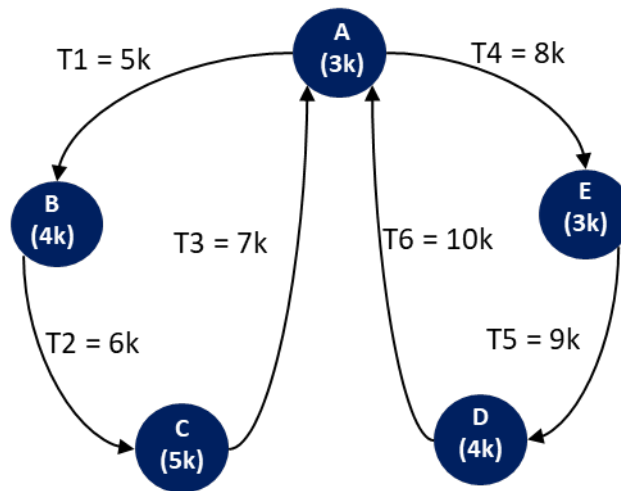
	A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)	Post LSM Netting Status		
Starting balance	3	4	5	4	3	Corda	Hyperledger Fabric	Quorum
T1	-5	+5				Settled	Settled	Settled
T2		-6	+6			Settled	Settled	Settled
T3			-7	+7		Settled	Settled	Settled
T4				-8	+8	Settled	Settled	Settled
T5	+7				-7	Settled	Settled	Settled
				A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)
Starting balance				3	4	5	4	3
Closing balance	Corda			5	3	4	3	4
	Hyperledger Fabric			5	3	4	3	4
	Quorum			5	3	4	3	4

2.5.2 Eight obligations, starting balance is 0 for all participants



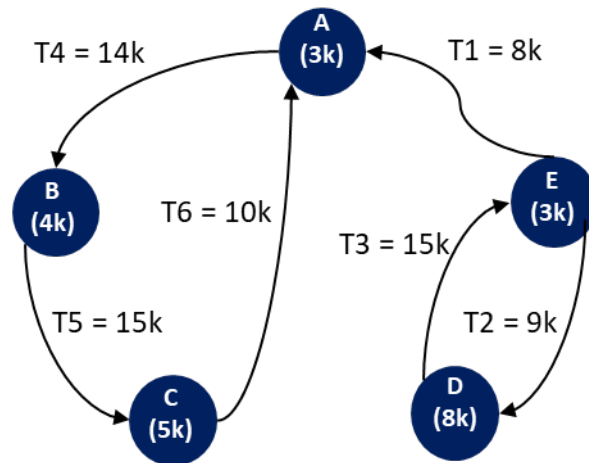
	A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)	Post LSM Netting Status		
Starting balance	0	0	0	0	0	Corda	Hyperledg er Fabric	Quorum
T1	-2	+2				Unsettled	Settled	Settled
T2		-3	+3			Unsettled	Settled	Settled
T3			-5	+5		Unsettled	Settled	Settled
T4				-6	+6	Unsettled	Settled	Settled
T5	+2				-2	Unsettled	Settled	Settled
T6		+1			-1	Unsettled	Settled	Settled
T7			+2		-2	Unsettled	Settled	Settled
T8				+1	-1	Unsettled	Settled	Settled
				A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)
Starting balance				0	0	0	0	0
Closing balance	Corda			0	0	0	0	0
	Hyperledger Fabric			0	0	0	0	0
	Quorum			0	0	0	0	0

2.5.3 Six obligations, 2 cycles with one common participate



	A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)	Post LSM Netting Status			
Starting balance	3	4	5	4	3	Corda	Hyperledger Fabric	Quorum	
T1	-5	+5				Settled	Settled	Settled	
T2		-6	+6			Settled	Settled	Settled	
T3	+7		-7			Settled	Settled	Settled	
T4	-8				+8	Settled	Settled	Settled	
T5				+9	-9	Settled	Settled	Settled	
T6	+10			-10		Settled	Settled	Settled	
					A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)
Starting balance					3	4	5	4	3
Closing balance	Corda				7	3	4	3	2
	Hyperledger Fabric				7	3	4	3	2
	Quorum				7	3	4	3	2

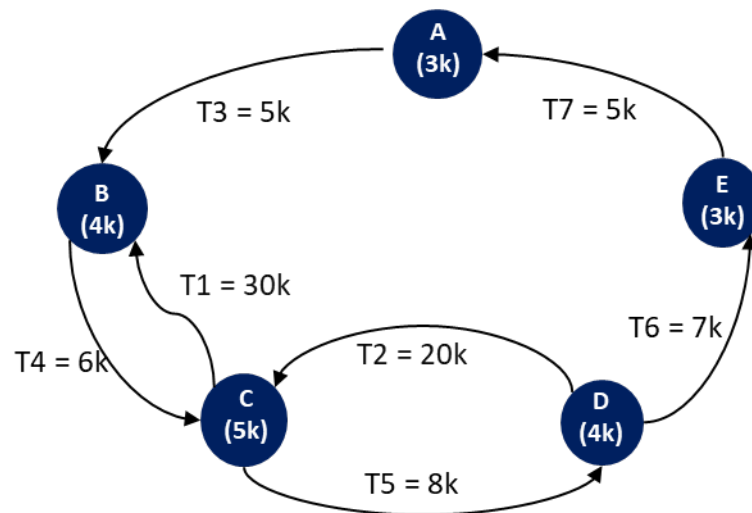
2.5.4 Six obligations, 2 cycles with no common participant - resolution of one gridlock depends on the resolution of another gridlock



	A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)	Post LSM Netting Status		
Starting balance	3	4	5	8	3	Corda	Hyperledger Fabric	Quorum
T1	+8				-8	Unsettled	Settled	Settled
T2				+9	-9	Settled	Settled	Settled
T3				-15	+15	Settled	Settled	Settled
T4	-14	+14				Unsettled	Settled	Settled
T5		-15	+15			Unsettled	Settled	Settled
T6	+10		-10			Unsettled	Settled	Settled
				A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)
Starting balance				3	4	5	8	3
Closing balance	Corda			3	4	5	2	9
	Hyperledger Fabric			7	3	10	2	1
	Quorum			7	3	10	2	1

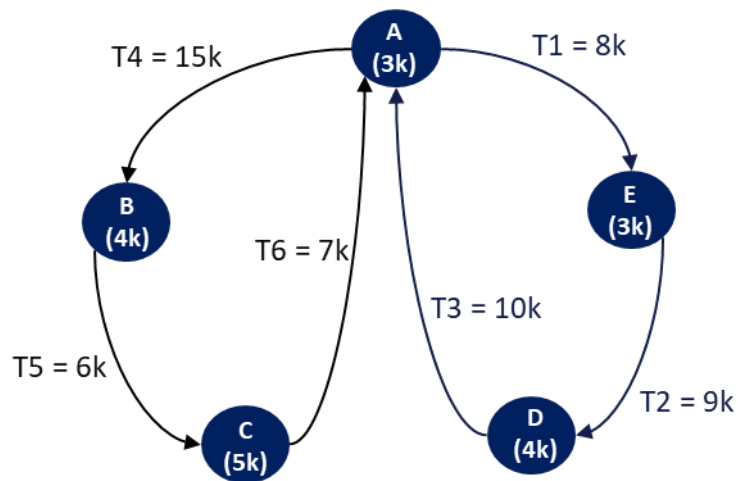
2.6 Five participants' gridlock partially resolved

2.6.1 Seven total obligations



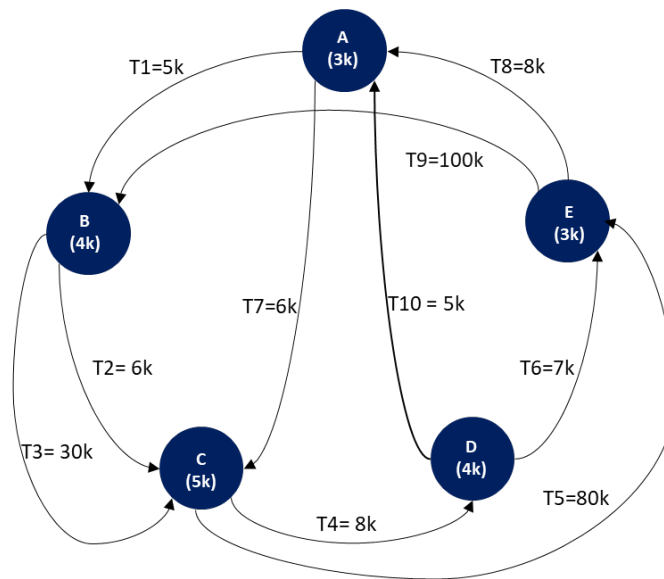
	A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)	Post LSM Netting Status		
Starting balance	3	4	5	4	3	Corda	Hyperledger Fabric	Quorum
T1		+30	-30			Unsettled	Unsettled	Unsettled
T2			+20	-20		Unsettled	Unsettled	Unsettled
T3	-5	+5				Settled	Unsettled	Unsettled
T4		-6	+6			Settled	Unsettled	Unsettled
T5			-8	+8		Settled	Unsettled	Unsettled
T6				-7	+7	Settled	Unsettled	Unsettled
T7	+5				-5	Settled	Unsettled	Unsettled
				A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)
Starting balance				3	4	5	4	3
Closing balance	Corda			3	3	3	5	5
	Hyperledger Fabric			3	4	5	4	3
	Quorum			3	4	5	4	3

2.6.2 Six total obligations, 2 cycles shared one common participant



	A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)	Post LSM Netting Status		
Starting balance	3	4	5	4	3	Corda	Hyperledger Fabric	Quorum
T1	-8				+8	Settled	Settled	Settled
T2				+9	-9	Settled	Settled	Settled
T3	+10			-10		Settled	Settled	Settled
T4	-15	+15				Unsettled	Unsettled	Unsettled
T5		-6	+6			Unsettled	Unsettled	Unsettled
T6	+7		-7			Unsettled	Unsettled	Unsettled
				A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)
Starting balance				3	4	5	4	3
Closing balance	Corda			5	4	5	3	2
	Hyperledger Fabric			5	4	5	3	2
	Quorum			5	4	5	3	2

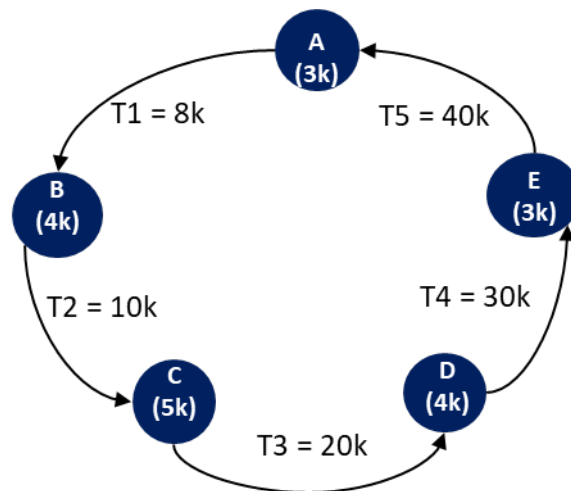
2.6.3 Ten total obligations



	A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)	Post LSM Netting Status		
Starting balance	3	4	5	4	3	Corda	Hyperledger Fabric	Quorum
T1	-5	+5				Settled	Settled	Settled
T2		-6	+6			Settled	Settled	Settled
T3		-30	+30			Unsettled	Unsettled	Unsettled
T4			-8	+8		Settled	Settled	Settled
T5			-80		+80	Unsettled	Unsettled	Unsettled
T6				-7	+7	Settled	Settled	Settled
T7	-6		+6			Settled	Settled	Settled
T8	+8				-8	Settled	Settled	Settled
T9		+100			-100	Unsettled	Unsettled	Unsettled
T10	+5			-5		Settled	Settled	Settled
				A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)
Starting balance				3	4	5	4	3
Closing balance	Corda			5	3	9	0	2
	Hyperledger Fabric			5	3	9	0	2
	Quorum			5	3	9	0	2

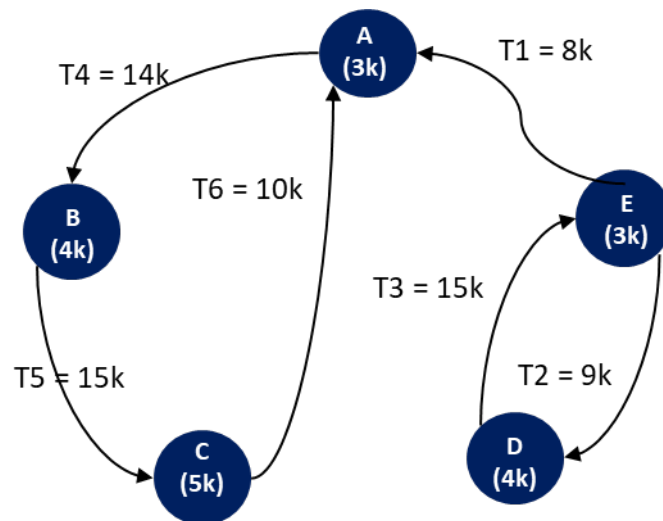
2.7 Five participants' deadlock

2.7.1 Five total obligations, 1 simple cycle



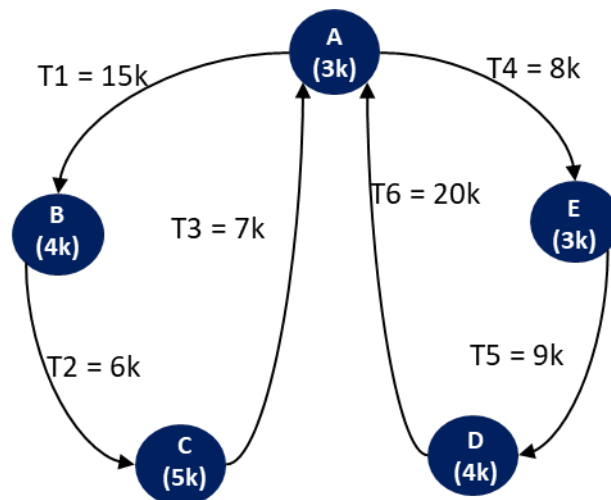
	A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)	Post LSM Netting Status		
Starting balance	3	4	5	4	3	Corda	Hyperledger Fabric	Quorum
T1	-8	+8				Unsettled	Unsettled	Unsettled
T2		-10	+10			Unsettled	Unsettled	Unsettled
T3		-20	+20			Unsettled	Unsettled	Unsettled
T4			-30	+30		Unsettled	Unsettled	Unsettled
T5	+40			-40		Unsettled	Unsettled	Unsettled
				A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)
Starting balance				3	4	5	4	3
Closing balance	Corda			3	4	5	4	3
	Hyperledger Fabric			3	4	5	4	3
	Quorum			3	4	5	4	3

2.7.2 Six total obligations, 2 cycles with no common participant



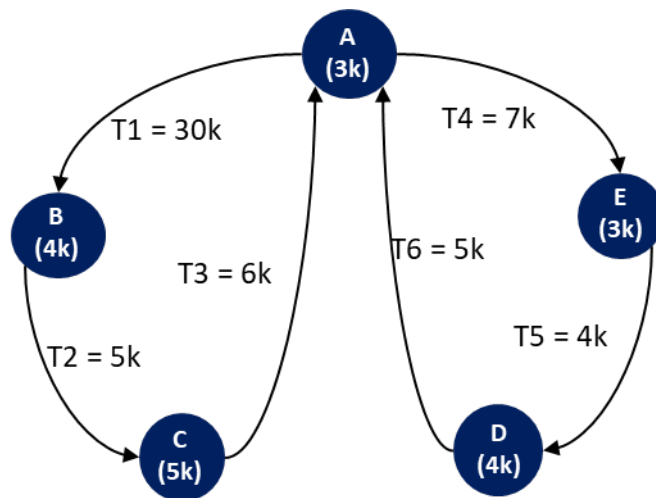
	A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)	Post LSM Netting Status		
Starting balance	3	4	5	4	3	Corda	Hyperledger Fabric	Quorum
T1	+8				-8	Unsettled	Unsettled	Unsettled
T2				+9	-9	Unsettled	Unsettled	Unsettled
T3				-15	+15	Unsettled	Unsettled	Unsettled
T4	-14	+14				Unsettled	Unsettled	Unsettled
T5		-15	+15			Unsettled	Unsettled	Unsettled
T6	+10		-10			Unsettled	Unsettled	Unsettled
				A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)
Starting balance				3	4	5	4	3
Closing balance	Corda			3	4	5	4	3
	Hyperledger Fabric			3	4	5	4	3
	Quorum			3	4	5	4	3

2.7.3 Six total obligations, 2 cycles with one common participant



	A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)	Post LSM Netting Status		
Starting balance	3	4	5	4	3	Corda	Hyperledger Fabric	Quorum
T1	-15	+15				Unsettled	Unsettled	Unsettled
T2		-6	+6			Unsettled	Unsettled	Unsettled
T3	+7		-7			Unsettled	Unsettled	Unsettled
T4	-8				+8	Unsettled	Unsettled	Unsettled
T5				+9	-9	Unsettled	Unsettled	Unsettled
T6	+20			-20		Unsettled	Unsettled	Unsettled
				A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)
Starting balance				3	4	5	4	3
Closing balance	Corda			3	4	5	4	3
	Hyperledger Fabric			3	4	5	4	3
	Quorum			3	4	5	4	3

2.7.4 Six total obligations, 2 cycles with one common participant



	A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)	Post LSM Netting Status		
Starting balance	3	4	5	4	3	Corda	Hyperledger Fabric	Quorum
T1	-30	+30				Unsettled	Unsettled	Unsettled
T2		-5	+5			Unsettled	Unsettled	Unsettled
T3	+6		-6			Unsettled	Unsettled	Unsettled
T4	-7				+7	Settled	Unsettled	Unsettled
T5				+4	-4	Settled	Unsettled	Unsettled
T6	+5			-5		Settled	Unsettled	Unsettled
				A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)
Starting balance				3	4	5	4	3
Closing balance	Corda			1	4	5	3	6
	Hyperledger Fabric			3	4	5	4	3
	Quorum			3	4	5	4	3