UBIN PHASE 2

Technical Documentation

Functional Testing

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

Table of Contents

1 Fur	nctional Testing	3
2 Tes	t Scenarios and Results	4
2.1 T	wo participants' gridlock fully resolved	4
2.1.1	Two obligations, starting balance is 0 for both participants	4
2.1.2	Two obligations	
2.1.3	Four obligations	6
2.2 T	wo participants' gridlock partially resolved	7
2.2.1	Four total obligations, starting balance is 0 for both participants	7
2.2.2	Five total obligations	8
2.2.3	Six total obligations	9
2.3 T	hree participants' gridlock fully resolved	10
2.3.1	Four obligations, starting balance is 0 for all participants	10
2.3.2	Five Obligations	11
2.3.3	Four obligations, 2 cycles with one common participant	12
2.4 T	hree participants' gridlock partially resolved	13
2.4.1	Four Total Obligations	13
2.4.2	Eight Obligations	14
2.4.3	Ten total obligations, 2 cycles with one common participant	15
2.4.4	Four total obligations, 2 cycles with one common participant	16
2.5 F	ive participants' gridlock fully resolved	17
2.5.1	Five Obligations of a simple cycle	17
2.5.2	Eight obligations, starting balance is 0 for all participants	18
2.5.3	Six obligations, 2 cycles with one common participate	19
2.5.4 depen	Six obligations, 2 cycles with no common participant - resolution of ods on the resolution of another gridlock	
2.6 F	ive participants' gridlock partially resolved	21
2.6.1	Seven total obligations	21
2.6.2	Six total obligations, 2 cycles shared one common participant	22
2.6.3	Ten total obligations	23
2.7 F	ive participants' deadlock	24
2.7.1	Five total obligations <mark>, 1 simple cycle</mark>	24
2.7.2	Six total obligations, 2 cycles with no common participant	25
2.7.3	Six total obligations, 2 cycles with one common participant	26
2.7.4	Six total obligations, 2 cycles with one common participant	27

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.

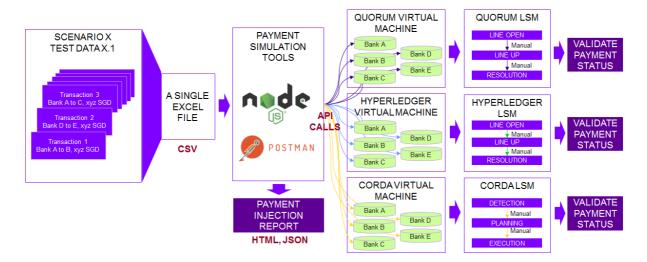
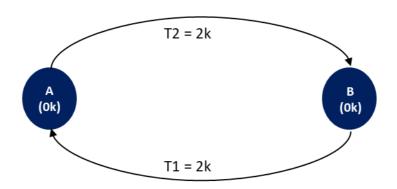


Figure 1:Test Setup and Test Approach

2 Test Scenarios and Results

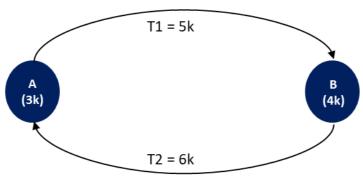
2.1 Two participants' gridlock fully resolved

2.1.1 Two obligations, starting balance is 0 for both participants



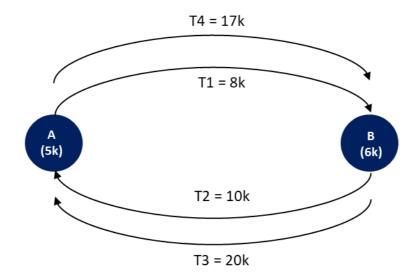
	A (\$k)	B (\$k)	Pos	t LSM N	etting St	atus	
Starting balance	0	0	Corda Hyperledge Fabric			Quorum	
T1	+2	-2	Settled	Settled		Settled	
T2	-2	+2	Settled	Settled		Settled	
			A (\$k)		B (\$k)		
Starting b	alance		0			0	
Closing	Co	rda	0		0		
balance	Hyperledg	ger Fabric	0	0		0	
	Quo	rum	0		0		

2.1.2 Two obligations



	A (\$k)	B (\$k)	Post LSM Netting Status					
Starting balance	3	4	Corda		Hyperledge Fabric	r Quorum		
T1	-5	+5	Settled		Settled	Settled		
T2	+6	-6	Settled		Settled	Settled		
					A (\$k)	B (\$k)		
	Starting ba	lance			3	4		
Closing		Corda		4		3		
balance	Нуре	erledger Fa	bric	4		3		
		Quorum			4	3		

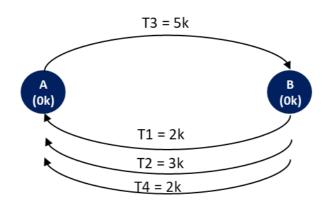
2.1.3 Four obligations



	A (\$k)	B (\$k)	Post LSM Netting Status			
Starting balance	5	6	Corda		ledger oric	Quorum
T1	-8	+8	Settled	Settled		Settled
T2	+10	-10	Settled	Settled		Settled
Т3	+20	-20	Settled	Settled		Settled
T4	-17	+17	Settled	Set	tled	Settled
			A (\$k)			B (\$k)
Sta	rting balance		5			6
Closing	Cord	а	10		1	
balance	Hyperledge	r Fabric	10		1	
	Quoru	ım	10	10		1

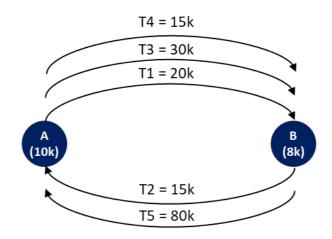
2.2 Two participants' gridlock partially resolved

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



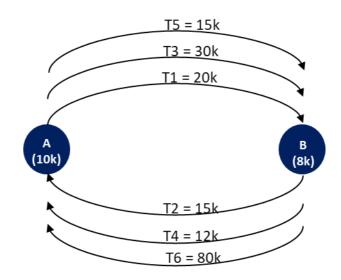
	A (\$k)	B (\$k)	Post LSM Netting Status				
Starting balance	0	0	Corda	Hyperledger Fabric		Quorum	
T1	+2	-2	Settled	Settled		Settled	
T2	+3	-3	Settled	Settled		Settled	
Т3	-5	+5	Settled	Settled		Settled	
T4	+2	-2	Unsettled	Unse	ettled	Unsettled	
			A (\$k)			B (\$k)	
Star	ting balance		0			0	
Closing	Corda		0		0		
balance	Hyperledge	er Fabric	0	0		0	
	Quor	um	0			0	

2.2.2 Five total obligations



	A (\$k)	B (\$k)	Post LSM Netting Status				
Starting balance	10	8	Corda		ledger oric	Quorum	
T1	-20	+20	Settled	Settled		Settled	
T2	+15	-15	Settled	Settled		Settled	
Т3	-30	+30	Unsettled	Unsettled		Unsettled	
T4	-15	+15	Unsettled	Unsettled		Unsettled	
T5	+80	-80	Unsettled	Unse	ettled	Unsettled	
			A (\$k)		B (\$k)		
Start	ing balance		10			8	
Closing	Cor	da	5			13	
balance	Hyperledg	er Fabric	5			13	
	Quor	um	5			13	

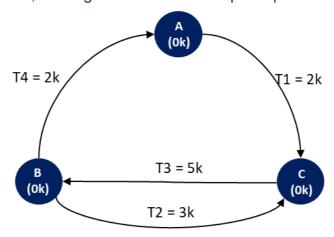
2.2.3 Six total obligations



	A (\$k)	B (\$k)	Post LSM Netting Status				
Starting balance	10	8	Corda		ledger oric	Quorum	
T1	-20	+20	Settled	Settled		Settled	
T2	+15	-15	Settled	Settled		Settled	
Т3	-30	+30	Unsettled	Unsettled		Unsettled	
T4	+12	-12	Settled	Unsettled		Settled	
T5	-15	+15	Settled	Unse	ettled	Unsettled	
Т6	+80	-80	Unsettled	Unse	ettled	Unsettled	
			A (\$k)			B (\$k)	
Sta	rting balance	е	10			8	
Closing	Co	rda	2		16		
balance	Hyperledg	ger Fabric	5		13		
	Quo	rum	17			1	

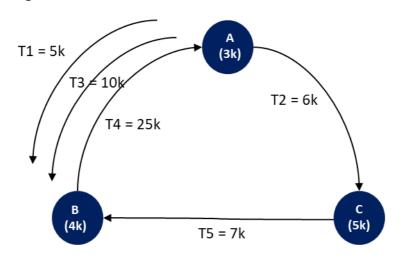
2.3 Three participants' gridlock fully resolved

2.3.1 Four obligations, starting balance is 0 for all participants



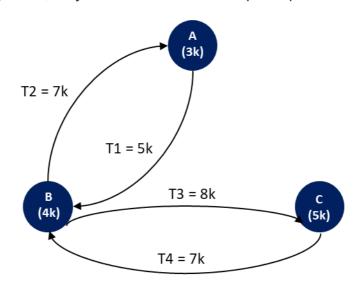
	A (\$k)	B (\$k)	C (\$k)	Post LSM Netting Status				
Starting balance	0	0	0	Corda	Hyperledge r Fabric	Quorum		
T1	-2		+2	Unsettled	Settled	Settled		
T2		-3	+3	Unsettled	Settled	Settled		
Т3		+5	-5	Unsettled	Settled	Settled		
T4	+2	-2		Unsettled	Settled	Settled		
				A (\$k)	B (\$k)	C (\$k)		
Start	ing bala	nce		0	0	0		
Closing		Corda		0	0	0		
balance	Нуре	rledger F	abric	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	
Т3	-10	+10		Unsettled	Settled	Settled	
T4	+25	-25		Unsettled	Settled	Settled	
T5		+7	-7	Unsettled	Settled	Settled	
				A (\$k)	B (\$k)	C (\$k)	
Start	ing bala	nce		3	4	5	
Closing		Corda		3	4	5	
balance	Нуре	rledger F	abric	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	
Т3		-8	+8	Settled	Settled	Settled	
T4		+7	-7	Settled	Settled	Settled	
				A (\$k)	B (\$k)	C (\$k)	
S	tarting ba	lance		3	4	5	
Closing		Corda		5	1	6	
balance	Hyperledger Fabric			5	1	6	

5

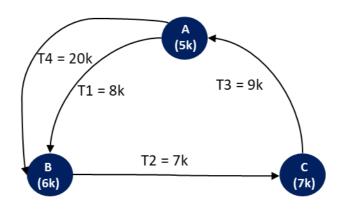
1

6

Quorum

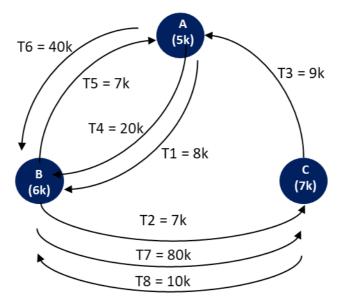
2.4 Three participants' gridlock partially resolved

2.4.1 Four Total Obligations



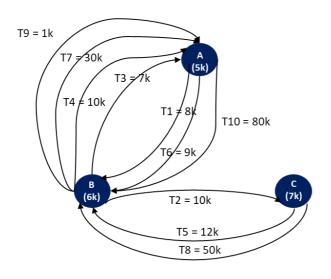
	A (\$k)	B (\$k)	C (\$k)	Post LSM Netting Status				
Starting balance	5	6	7	Corda	Hyperledge r Fabric	Quorum		
T1	-8	+8		Settled	Settled	Settled		
T2		-7	+7	Settled	Settled	Settled		
Т3	+9		-9	Settled	Settled	Settled		
T4	-20	+20		Unsettled	Unsettled	Unsettled		
				A (\$k)	B (\$k)	C (\$k)		
	Starting	balance		5	6	7		
Closing		Corda		6	7	5		
balance	balance Hyperledger Fabric			6	7	5		
		Quorum		6	7	5		

2.4.2 Eight Obligations



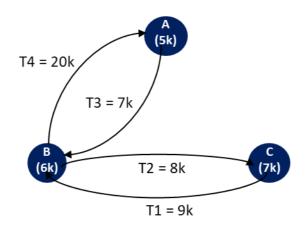
	A (\$k)	B (\$k)	C (\$k)	Post	LSM Netting St	tatus
Starting balance	5	6	7	Corda	Hyperledger Fabric	Quorum
T1	-8	+8		Settled	Settled	Settled
T2		-7	+7	Settled	Settled	Settled
Т3	+9		-9	Settled	Settled	Settled
T4	-20	+20		Unsettled	Unsettled	Unsettled
T5	+7	-7		Unsettled	Settled	Settled
Т6	-40	+40		Unsettled	Unsettled	Unsettled
T7		-80	+80	Unsettled	Unsettled	Unsettled
Т8		+10	-10	Unsettled	Unsettled	Unsettled
				A (\$k)	B (\$k)	C (\$k)
	Starting	balance		5	6	7
Closing		Corda		6	7	5
balance	balance Hyperledger Fabric		abric	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 S	tatus
Starting balance	5	6	7	Corda	Hyperledger Fabric	Quorum
T1	-8	+8		Settled	Settled	Settled
T2		-10	+10	Settled	Settled	Settled
Т3	+7	-7		Settled	Settled	Settled
T4	+10	-10		Settled	Settled	Settled
T5		+12	-12	Settled	Settled	Settled
Т6	-9	+9		Settled	Settled	Settled
Т7	+30	-30		Unsettled	Unsettled	Unsettled
Т8		+50	-50	Unsettled	Unsettled	Unsettled
Т9	+10	-10		Unsettled	Unsettled	Unsettled
T10	-80	+80		Unsettled	Unsettled	Unsettled
				A (\$k)	B (\$k)	C (\$k)
S	tarting b	alance		5	6	7
Closing balance		Corda		5	8	5
Dalatice	Нуре	rledger F	abric	5	8	5
		Quorum		5	8	5

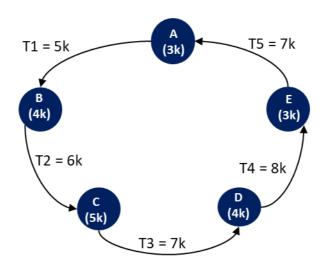
2.4.4 Four total obligations, 2 cycles with one common participant



	A (\$k)	B (\$k)	C (\$k)	Post	LSM Netting St	atus
Starting balance	5	6	7	Corda	Hyperledger Fabric	Quorum
T1		+9	-9	Settled	Settled	Settled
T2		-8	+8	Settled	Settled	Settled
Т3	-7	+7		Unsettled	Unsettled	Unsettled
T4	+20	-20		Unsettled	Unsettled	Unsettled
				A (\$k)	B (\$k)	C (\$k)
	Starting	balance		5	6	7
Closing		Corda		5	7	6
balance	Нуре	erledger Fa	abric	5	7	6
		Quorum		5	7	6

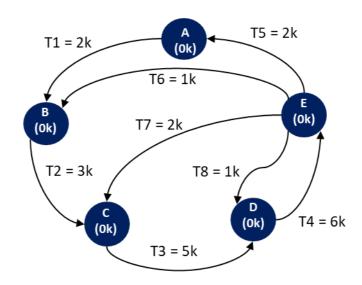
2.5 Five participants' gridlock fully resolved

2.5.1 Five Obligations of a simple cycle



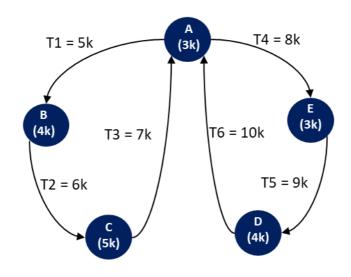
	A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)	Post LSM Netting Status						
Starting balance	3	4	5	4	3	Corda		rledger ibric	Quorum			
T1	-5	+5				Settled	Se	ettled	Settled			
T2		-6	+6			Settled	Se	ettled	Settled			
Т3			-7	+7		Settled	Se	ettled	Settled			
T4				-8	+8	Settled	Se	ettled	Settled			
T5	+7				-7	Settled	Se	ettled	Settled			
				A	(\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)			
St	arting b	alance			3	4	5	4	3			
Closing		Corda	1	:	5	3	4	3	4			
balance	Нуре	rledger	Fabric	;	5	3	4	3	4			
		Quorur	m		5	3	4	3	4			

2.5.2 Eight obligations, starting balance is 0 for all participants



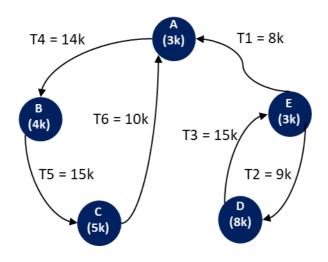
	A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)		Post LSM Netting Status						
Starting balance	0	0	0	0	0	Cord	а		erledg abric	Quorum			
T1	-2	+2				Unsettl	ed	Se	ttled	Settled			
T2		-3	+3			Unsettl	ed	Se	ttled	Settled			
Т3			-5	+5		Unsettl	ed	Se	ttled	Settled			
T4				-6	+6	Unsettl	ed	Se	ttled	Settled			
T5	+2				-2	Unsettl	Unsettled		ttled	Settled			
Т6		+1			-1	Unsettl	ed	Se	ttled	Settled			
Т7			+2		-2	Unsettl	ed	Se	ttled	Settled			
Т8				+1	-1	Unsettl	ed	Se	ttled	Settled			
				Α	(\$k)	B (\$k)	С	(\$k)	D (\$k)	E (\$k)			
St	arting	balance)		0	0		0	0	0			
Closing		Corda	a		0	0		0	0	0			
balance	Нуре	erledge	r Fabric		0	0		0	0	0			
		Quoru	m		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)	Po	tus		
Starting balance	3	4	5	4	3	Corda		rledger bric	Quorum
T1	-5	+5				Settled	Se	ttled	Settled
T2		-6	+6			Settled	Se	ttled	Settled
Т3	+7		-7			Settled	Se	ttled	Settled
T4	-8				+8	Settled	Se	ttled	Settled
T5				+9	-9	Settled	Se	ttled	Settled
Т6	+10			-10		Settled	Se	ttled	Settled
					A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)
8	Starting	j balan	се		3	4	5	4	3
Closing		Cor	da		7	3	4	3	2
balance	Нур	erledg	er Fabı	ric	7	3	4	3	2
		Quor	um		7	3	4	3	2

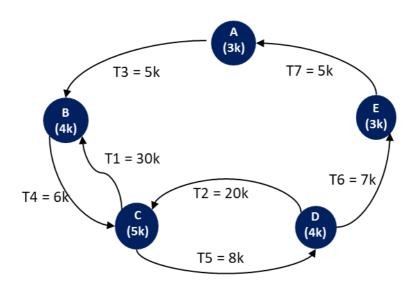
2.5.4 Six obligations, 2 cycles with no common participant - resolution of one gridlock depends on the resolution of another gridlock



	A (\$k)	B (\$k)	C (\$k)	D (\$k		Po	ost I	LSM Ne	etting Sta	tus
Starting balance	3	4	5	8	3	Corda	l		rledger ibric	Quorum
T1	+8				-8	Unsettle	ed	Se	ettled	Settled
T2				+9	9 -9	Settled	ł	Se	ettled	Settled
Т3				-18	5 +15	Settled	ł	Se	ettled	Settled
T4	-14	+14				Unsettle	ed	Se	ettled	Settled
T5		-15	+15			Unsettle	ed	Se	ettled	Settled
Т6	+10		-10			Unsettle	ed	Se	ettled	Settled
					A (\$k)	B (\$k)	С	(\$k)	D (\$k)	E (\$k)
St	arting l	balance)		3	4		5	8	3
Closing		Cord	а		3	4		5	2	9
balance	Нур	erledge	r Fabri	С	7	3		10	2	1
		Quoru	ım		7	3		10	2	1

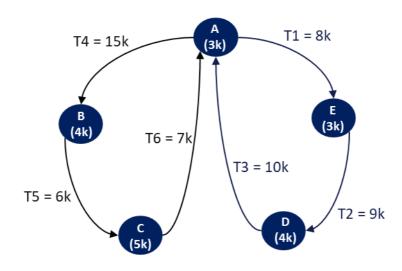
2.6 Five participants' gridlock partially resolved

2.6.1 Seven total obligations



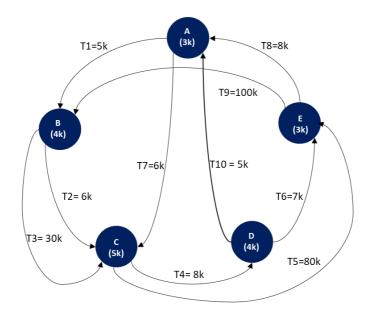
	A (\$k)	B (\$k)	C (\$k)	D (\$k		E (\$k)	Post LSM Netting Status					us
Starting balance	3	4	5	4		3	Corda		Hyper Fal	ledger oric	(Quorum
T1		+30	-30				Unsettle	d	Unse	ettled	l	Jnsettled
T2			+20	-20	0		Unsettle	d	Unse	ettled	ι	Jnsettled
Т3	-5	+5					Settled		Unse	ettled	ι	Jnsettled
T4		-6	+6				Settled		Unse	ettled	ι	Jnsettled
T5			-8	+8	3		Settled		Unse	ettled	l	Jnsettled
Т6				-7	,	+7	Settled		Unse	ettled	ι	Jnsettled
T7	+5					-5	Settled		Unset	tled	U	nsettled
					Α	(\$k)	B (\$k)		C (\$k)	D (\$	k)	E (\$k)
	Starting	balanc	е			3	4		5	4		3
Closing		Corda				3	3		3	5		5
balance	Нур	erledge	r Fabric	;		3	4		5	5 4		3
		Quoru	ım			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)	Ро	est LSM Netting Status					
Starting balance	3	4	5	4	3	Corda	Hyperle Fabr		(Quorum		
T1	-8				+8	Settled	Settled			Settled		
T2				+9	-9	Settled	Settle	ed		Settled		
Т3	+10			-10		Settled	Settle	ed		Settled		
T4	-15	+15				Unsettled	Unsettled		L	Insettled		
T5		-6	+6			Unsettled	Unsett	led	L	Insettled		
Т6	+7		-7			Unsettled	Unsett	led	L	Insettled		
					A (\$k)	B (\$k)	C (\$k)	D (\$	k)	E (\$k)		
S	tarting	baland	се		3	4	5			3		
Closing		Core	da		5	4	5	3		2		
balance	Нур	erledg	er Fabı	ric	5	4	5	5 3		2		
		Quor	um		5	4	5	3		2		

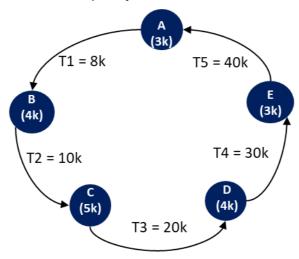
2.6.3 Ten total obligations



	A (\$k)	B (\$k)	C (\$k)	D E (\$k)			tus				
Starting balance	3	4	5	4	3		Cor	da		erledger Fabric	Quorum
T1	-5	+5					Sett	led	5	Settled	Settled
T2		-6	+6				Sett	led	5	Settled	Settled
Т3		-30	+30				Unse	ttled	U	nsettled	Unsettle d
T4			-8	+8			Sett	led	5	Settled	Settled
Т5			-80		+8	0	Unse	ttled	U	nsettled	Unsettle d
Т6				-7	+7	7	Sett	led	5	Settled	Settled
T7	-6		+6				Sett	led	5	Settled	Settled
Т8	+8				-8		Sett	led	5	Settled	Settled
Т9		+100			-10	0	Unse	ttled	U	nsettled	Unsettle d
T10	+5			-5			Sett	led	9	Settled	Settled
				A (\$	k)	Е	3 (\$k)	C (\$	ik)	D (\$k)	E (\$k)
St	arting b	alance		3			4	5		4	3
Closing		Corda		5			3	9		0	2
balance	Нуре	rledger	Fabric	5			3	9		0	2
		Quorum	1	5			3	9	0		2

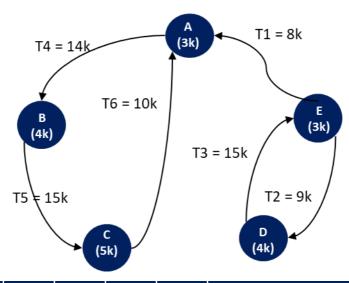
2.7 Five participants' deadlock

2.7.1 Five total obligations, 1 simple cycle



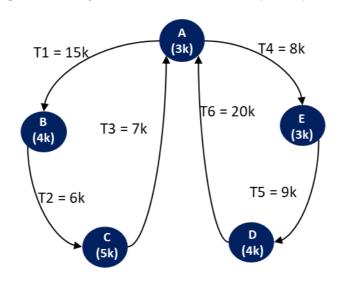
	A (\$k)	B (\$k)	C (\$k)	D (\$k)	(\$k))	Post I	_SM	Netti	ng Statu	IS	
Starting balance	3	4	5	4	3		Corda	1	Hyp ger Fab		C	luorum
T1	-8	+8					Unset	tled	Uns	ettled	U	Insettled
T2		-10	+10				Unset	tled	Uns	ettled	U	Insettled
Т3		-20	+20				Unset	tled	Uns	ettled	U	Insettled
T4			-30	+30			Unset	tled	Uns	settled	U	Insettled
T5	+40			-40			Unset	tled	Uns	ettled	U	Insettled
				A (\$k)	E	3 (\$k)	C (\$k)	D (\$k))	E (\$k)
Sta	arting b	alance		3	3		4	ţ	5	4		3
Closing balance		Corda	1	3	3		4	Ę	5	4		3
Dalalioe	Нуре	rledger	Fabric	3	3		4	5	5	4		3
		Quoru	m	3	3		4	Ę	5	4		3

2.7.2 Six total obligations, 2 cycles with no common participant



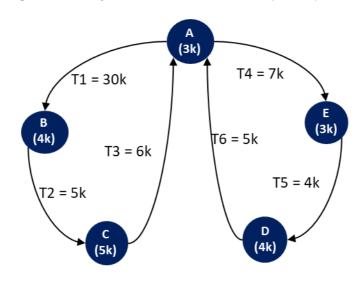
	A (\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)		Post LSM Netting Statu				
Starting balance	3	4	5	4	3	Corda	<i>,</i> ,	rledger bric	Quorum		
T1	+8				-8	Unsettle	ed Uns	ettled	Unsettled		
T2				+9	-9	Unsettle	ed Uns	ettled	Unsettled		
Т3				-15	+15	Unsettle	ed Uns	ettled	Unsettled		
T4	-14	+14				Unsettle	ed Uns	ettled	Unsettled		
T5		-15	+15			Unsettle	ed Uns	ettled	Unsettled		
Т6	+10		-10			Unsettle	ed Uns	ettled	Unsettled		
				Α	(\$k)	B (\$k)	C (\$k)	D (\$k)	E (\$k)		
S	tarting	balance)		3	4	5	4	3		
Closing		Corda	a		3	4	5	4	3		
balance	Нуре	erledge	Fabric		3	4	5	4	3		
		Quoru	m		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 S	tatus	
Starting balance	3	4	5	4	3	(Cord	а		rledger bric	Quor	um
T1	-15	+15				Uı	nsettl	ed	Uns	ettled	Unset	tled
T2		-6	+6			Uı	nsettl	ed	Uns	ettled	Unset	tled
Т3	+7		-7			Uı	nsettl	ed	Uns	ettled	Unset	tled
T4	-8				+8	Uı	Unsettled		Unsettled		Unsettled	
T5				+9	-9	Uı	nsettl	ed	Uns	ettled	Unset	tled
Т6	+20			-20		Uı	nsettl	ed	Uns	ettled	Unset	tled
				A (\$k)	В (\$	Sk)	С	(\$k)	D (\$k)	E (\$k)
S	tarting l	balance		3	3	4			5	4	3	3
Closing		Corda	l	3	3	4		5		4	3	3
balance	Нуре	rledger	Fabric	3	3	4		5		4	3	3
		Quorur	n	3	3	4			5	4	3	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	Cord	da		erledger abric	Quorum
T1	-30	+30				Unset	Unsettled		settled	Unsettled
T2		-5	+5			Unset	nsettled U		settled	Unsettled
Т3	+6		-6			Unset	Jnsettled I		settled	Unsettled
T4	-7				+7	Settl	Settled		settled	Unsettled
T5				+4	-4	Settl	Settled		settled	Unsettled
Т6	+5			-5		Settl	Settled		settled	Unsettled
				A (\$	A (\$k)		C (\$k)	D (\$k)	E (\$k)
Starting balance				3	3		5		4	3
Closing balance	Corda			1		4	Į.	5	3	6
	Hyperledger Fabric			3		4	!	5	4	3
	Quorum			3		4		5	4	3