Self-downgrade MESI Protocol

Approach

Firstly, I write a MSI protocol. In order to tackle the reordering messages, I use additional transient like TRIS with TRIF to receive two messages without considering order. For example, FwdReadReq and WBStaleReadAck are sent to M node, when WBStaleReadAck arrives first, it will reach the TRIS state, otherwise, if FwdReadReq reaches first, it will be TRIF, and they both will be I node eventually. However, majority of reordering messages sequence are guaranteed by Nack. In the optimized version, I designed a self-downgraded MESI protocol. However, because of the deadlock problem, all of reordering messages are guaranteed by Nack.

S state nodes evict silently, so the actual share state nodes number is likely to be less than the shares in Shareslist. but E node evicts with evict request to Home node.

E state is really unstable, and self-downgrade makes it even worse. With so many rules sent spontaneously by E node, when Home state is E, the processor is likely to be M (E write), TEI (having clean evict), PTMX(E write to be M and having dirty evict). Because of this, E is regarded as M by Home node in advance. For example, with E state in home, when a node send a ReadReq to Home, home will send a FwdReadReq to E node. Furthermore, a lot of additional transient states are added in Home and Processor.

Protocol
Visual Channel
ReqVC: 0;   -- low priority
FwdVC: 1;
AckVC: 2;   -- high priority

MSI
States:
HM, HS, HI, TMM, TMS
PM, PS, PI,
TIS, TIL,   -- I to S and S to I
IM, IIM, TRIS, TRIF, TMI, TMII, TWIS, TWIF -- I to M and M to I

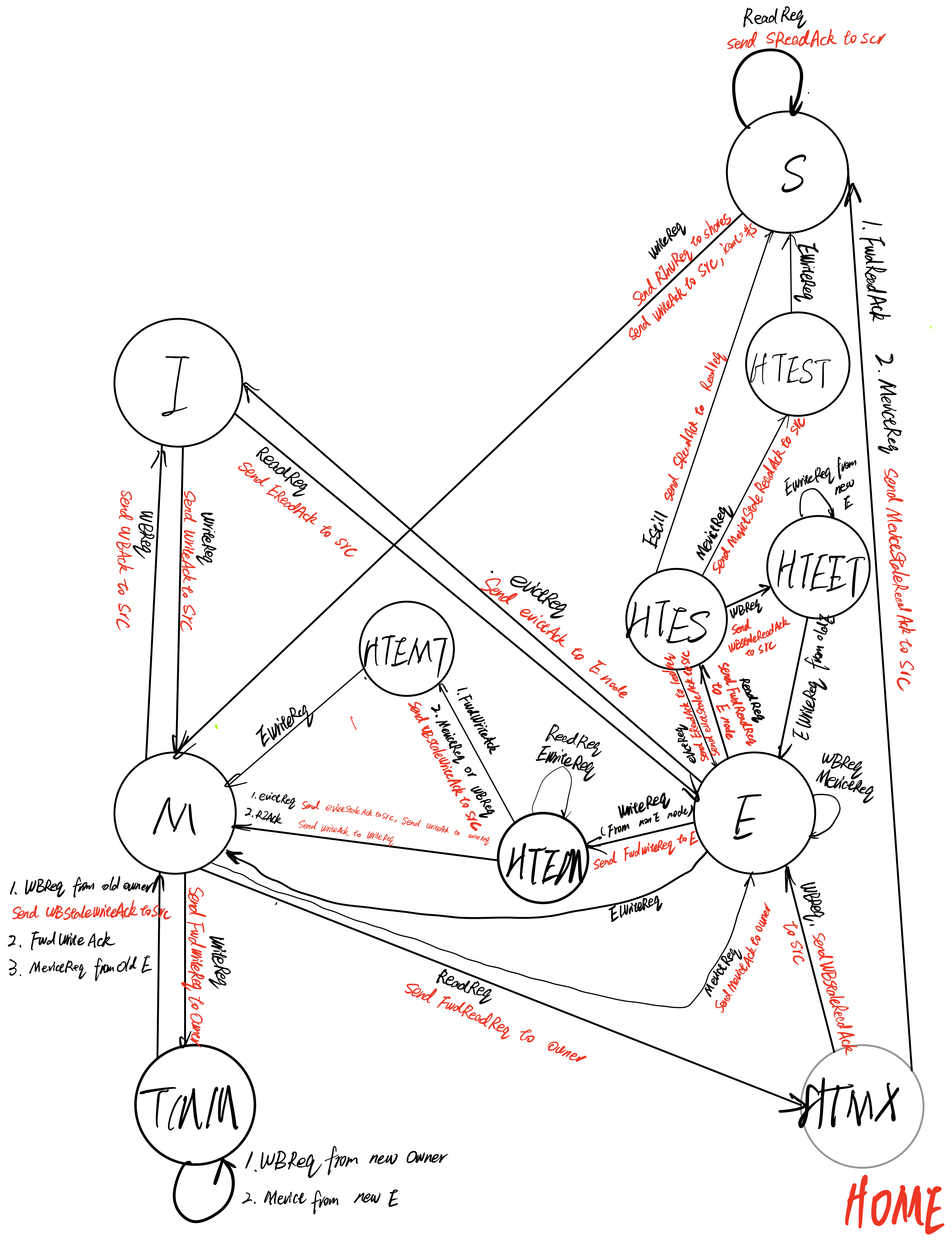
Messages:
ReadReq – ReadAck – FwdReadReq – FwdReadAck ReadFwd
WriteReq – WriteAck – FwdWriteReq – FwdWriteAck WriteFwd
WBReq - WBAck
WBStaleReadAck, -- wb ack, but other node has issued a read to Home Node
WBStaleWriteAck, -- wb ack, but other node has issued a write to Home Node
RinvReq - RIAck

MESI(MSI_OPT)
States:
HM, HS, HI, HE, TMM, HTMX, HTEM, HTEMT, HTES, HTEST, HTEET

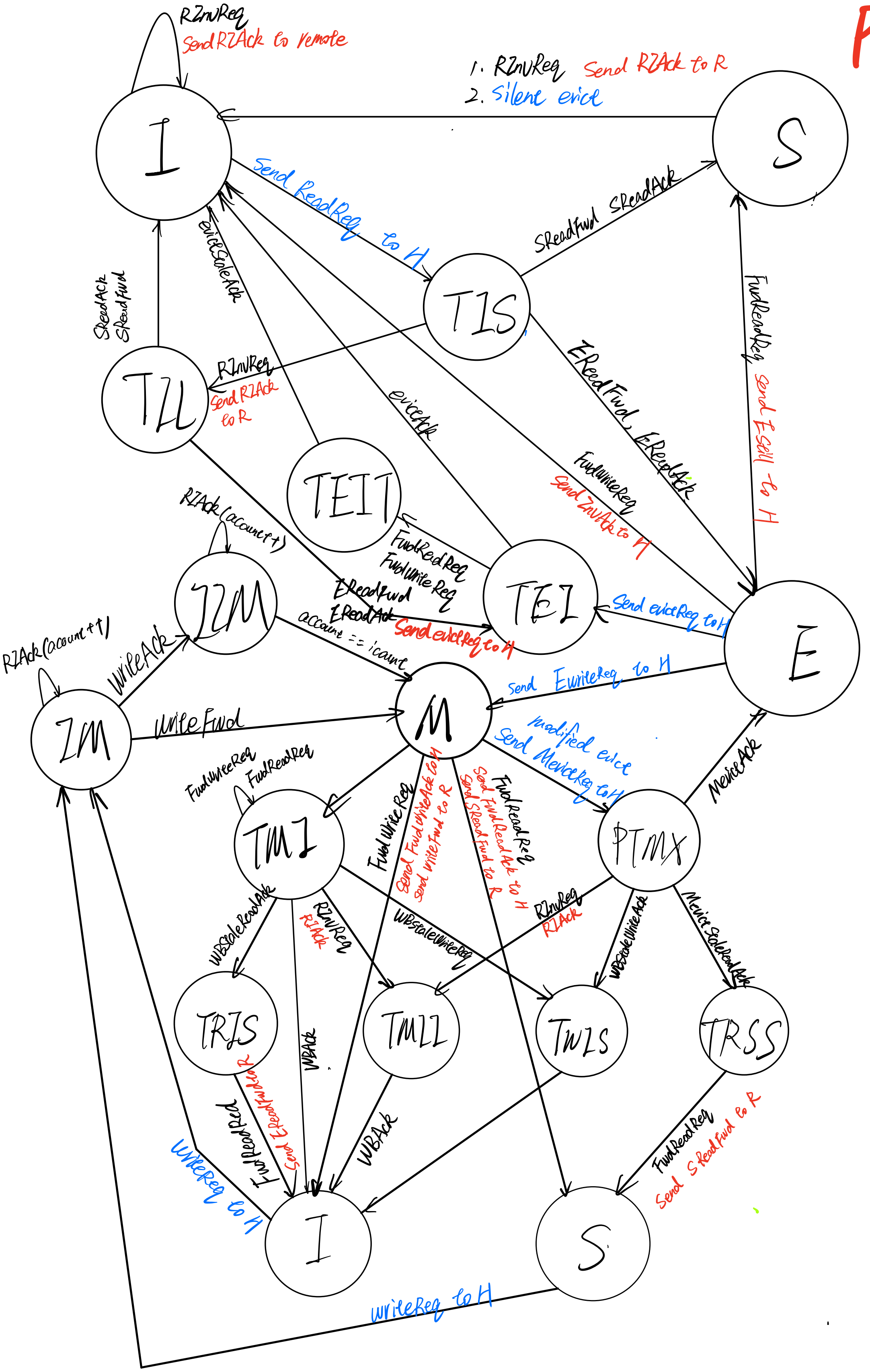
PM, PS, PI, PE,
TIS, TIL, TEI, TEIT, --TSI, TSIT,
-- I to S and S to I
IM, IIM, TRIS, TRIF, TMI, TMII, TWIS, TWIF,
-- I to M and M to I
PTMX, TRSF, TRSS
-- self-downgrade
Messages:
ReadReq – EReadAck SReadAck– FwdReadReq – FwdReadAck EReadFwd SReadFwd
WriteReq – WriteAck – FwdWriteReq – FwdWriteAck WriteFwd
WBReq - WBAck
- WBStaleReadAck, -- wb ack, but other node has issued a read to Home Node
- WBStaleWriteAck, -- wb ack, but other node has issued a write to Home Node
RInvReq - RIAck
InvAck – E send it to node to ensure Inv
evictReq - evictAck - evictStaleAck --E evict request
MevictReq – MevictAck - MevictStaleReadAck - MevictStaleWriteAck --M down grade request
EWriteReq – E Processor write without needing to request Home
EStill –Proc E state is still

Optimization
Self-downgraded MESI protocol

E is regarded as M by Home node in advance because of the unstable E state. When Home node is E state, Home state transaction is very completed in order to judge if E node has actually changed it state.


Read Req
send SReadAck to scr
S
WriteReq
Send RInvReq to shares
Send WriteAck to src, count=#S
EWriteReq
1. FwdReadAck
2. MeviceReq
Send MeviceStaleReadAck to SrC
HTEST
ESc'll
send SReadAck to ReadReq
MeviceReq
Send MeviceStaleReadAck to SrC
EWriteReq from new E
HTEET
HTES
WBReq
Send WBStaleReadAck to SrC
E WriteReq from old
eviceReq
send EReadAck to leader
Send eviceStaleAck to SrC
ReadReq
Send FwdReadReq to E node
I
ReadReq
Send EReadAck to SrC
eviceReq
Send eviceAck to E node
WBReq
Send WBAck to SrC
WriteReq
Send WriteAck to SrC
HTEMT
EWriteReq
1. FwdWriteAck
2. MeviceReq or WBReq
Send WBStaleWriteAck to SrC
ReadReq
EWriteReq
M
1. eviceReq Send eviceStaleAck to SrC, Send WriteAck to WriteReq
2. R2Ack Send WriteAck to WriteReq
HTEM
WriteReq (From non E node)
Send FwdWriteReq to E
E
WBReq
MeviceReq
EWriteReq
1. WBReq from old owner
Send WBStaleWriteAck to SrC
2. Fwd Write Ack
3. MeviceReq from old E
WriteReq
Send FwdWriteReq to Owner
ReadReq
Send FwdReadReq to owner
MeviceReq
Send MeviceAck to owner
WBReq, Send WBStaleReadAck to SrC
TCWM
1. WBReq from new Owner
2. Mevice from new E
HTMX
HOME

PROCESSOR



I
S
TIS
TIL
TEIT
TEI
E
I2M
IM
M
TMI
PTMX
TRIS
TMII
TWIS
TRSS
I
S
RInvReq
Send RIAck to remote
1. RInvReq Send RIAck to R
2. Silent evict
Send ReadReq to H
SReadFwd SReadAck
SReadAck
SReadFwd
evictStaleAck
RInvReq
Send RIAck to R
evictAck
FwdReadReq
Send ESell to H
EReadFwd, EReadAck
FwdWriteReq
Send InvAck to H
FwdReadReq
FwdWrite Req
EReadFwd
EReadAck
Send evictReq to H
Send evictReq to H
RIAck (acount++)
RIAck (acount++)
writeAck
acount == icount
writeFwd
Send EwriteReq to H
modified evict
Send MevictReq to H
MevictAck
FwdWriteReq
FwdReadReq
FwdWriteReq
Send FwdWriteAck to H
Send writeFwd to R
FwdReadReq
Send FwdReadAck to H
Send SReadFwd to R
WBStaleReadAck
RInvReq
RIAck
WBStaleWriteReq
RInvReq
RIAck
WBStaleWriteAck
MevictStaleReadAck
WBAck
WBAck
FwdReadReq
Send EReadFwd to R
writeReq to H
FwdReadReq
Send SReadFwd to R
writeReq to H