Abbreviations \sim M_1 = senckey((fAKID((fATID(SUPI,K),ID_MNO_5)),ID_AF_5, \sim M_4 = ID_MNO_5 \sim M 8 = ID MNO 5 ID_AF_5) **Honest Process** Attacker {1}new ID_MNO_5 {2}new ID_AF_5 \sim M = pk(SK MNO) Beginning of process AF {91} insert choosechannel(ID_MNO_5,chMNOAF) Beginning of process AF {91} insert choosechannel(ID_MNO_5,chMNOAF) Beginning of process MNO {54} event MNOhasKAKMA(fKAKMA(SUPI,K)) {56} event MNOhasAKID(fAKID((fATID(SUPI,K),ID_MNO_5))) {57} event indatabase(fAKID((fATID(SUPI,K),ID MNO 5)), SUPI,fKAKMA(SUPI,K)) {58} insert database(fAKID((fATID(SUPI,K),ID_MNO_5)), SUPI,fKAKMA(SUPI,K)) Beginning of process UE Beginning of process UE {14} event UEhasKAKMA(fKAKMA(SUPI,K)) {14} event UEhasKAKMA(fKAKMA(SUPI,K)) {17} event UEhasAKID(fAKID((fATID(SUPI,K),ID_MNO_5))) | {17} event UEhasAKID(fAKID((fATID(SUPI,K),ID_MNO_5))) {19} event UEhasKAF(fKAF(ID_AF_5,fKAKMA(SUPI,K))) {19}event UEhasKAF(fKAF(ID_AF_5,fKAKMA(SUPI,K))) {22} event UEhasT(hmac((user_id,ID_AF_5),K_UE)) {22} event UEhasT(hmac((user_id,ID_AF_5),K_UE)) {24} new rUE_2 {24} new rUE_1 Beginning of process MNO {26} event UEhasKsh(KEMkey(Encaps(pk(SK_MNO),rUE_2))) {26} event UEhasKsh(KEMkey(Encaps(pk(SK_MNO),rUE_1))) {54} event MNOhasKAKMA(fKAKMA(SUPI,K)) {29} event UEhasN(senckey((fAKID((fATID(SUPI,K), ID_MNO_5)),ID_AF_5,hmac((user_id,ID_AF_5),K_UE)), {29} event UEhasN(senckey((fAKID((fATID(SUPI,K), ID_MNO_5)),ID_AF_5,hmac((user_id,ID_AF_5),K_UE)), {56} event MNOhasAKID(fAKID((fATID(SUPI,K),ID MNO 5))) KEMkey(Encaps(pk(SK_MNO),rUE_1)))) KEMkey(Encaps(pk(SK_MNO),rUE_2)))) {57} event indatabase(fAKID((fATID(SUPI,K),ID_MNO_5)), {32} event UEhasKpAF(KDF2(KEMkey(Encaps(pk(SK_MNO), rUE_1)),fKAF(ID_AF_5,fKAKMA(SUPI,K))) {32} event UEhasKpAF(KDF2(KEMkey(Encaps(pk(SK_MNO), SUPI,fKAKMA(SUPI,K)) rUE_2)),fKAF(ÌD_AF_5,fKAKMA(SUPĬ,K))) {58} insert database(fAKID((fATID(SUPI,K),ID_MNO_5)), {33} event UEsendReqAF(senckey((fAKID((fATID(SUPI, K),ID_MNO_5)),ID_AF_5,hmac((user_id,ID_AF_5),K_UE)), {33} event UEsendReqAF(senckey((fAKID((fATID(SUPI, K),ID_MNO_5)),ID_AF_5,hmac((user_id,ID_AF_5),K_UE)), SUPI,fKAKMA(SUPI,K)) KEMkey(Encaps(pk(SK_MNO),rUE_1))),hmac(senckey(fAKID((fATID(SUPI,K),ID_MNO_5)),ID_AF_5,hmac(KEMkey(Encaps(pk(SK_MNO),rUE_2))),hmac(senckey((fAKID((fATID(SUPI,K),ID MNO 5)),ID AF 5,hmac((user_id,ID_AF_5),K_UE)),KEMkey(Encaps(pk(SK_MNO),rUE_1))),KEMkey(Encaps(pk(SK_MNO),rUE_1))),ID_MNO_5) (user_id,ID_AF_5),K_UE)),KEMkey(Encaps(pk(SK_MNO), rUE_2))),KEMkey(Encaps(pk(SK_MNO),rUE_2))),ID_MNO_5) {34} event UEbegin(senckey((fAKID((fATID(SUPI,K), {34} event UEbegin(senckey((fAKID((fATID(SUPI,K), ID MNO 5)), ID AF 5, hmac((user id, ID AF 5), K UE)), ID MNO 5)), ID AF 5, hmac((user id, ID AF 5), K UE)), KEMkey(Encaps(pk(SK_MNO),rUE_2)))) KEMkey(Encaps(pk(SK_MNO),rUE_1)))) $(\sim M_1, \sim M_2, \sim M_3, \sim M_4)$ $(\sim M_5, \sim M_6, \sim M_7, \sim M_8)$ $(\sim M_5, \sim M_6, \sim M_7, \sim M_4)$ {93} event AFbegin(senckey((fAKID((fATID(SUPI,K), ID_MNO_5)),ID_AF_5,hmac((user_id,ID_AF_5),K_UE)), KEMkey(Encaps(pk(SK_MNO),rUE_2)))) {94} event AFrecReqUE(senckey((fAKID((fATID(SUPI, K), ID MNO 5)), ID AF 5, hmac((user id, ID AF 5), K UE)), KEMkey(Encaps(pk(SK_MNO),rUE_2))),hmac(senckey((fAKID((fATID(SUPI,K),ID MNO 5)),ID AF 5,hmac((user id,ID AF 5),K UE)),KEMkey(Encaps(pk(SK MNO), rUE_2))),KEMkey(Éncaps(pk(SK_MNO),rUE_2))),ID_MNO_5) {95} event AFhasN(senckey((fAKID((fATID(SUPI,K), ID_MNO_5)),ID_AF_5,hmac((user_id,ID_AF_5),K_UE)), KEMkey(Encaps(pk(SK MNO),rUE 2)))) {108} get choosechannel(ID MNO 5,chMNOAF) {96} event AFsendReqMNO(senckey((fAKID((fATID(SUPI, K),ID_MNO_5)),ID_AF_5,hmac((user_id,ID_AF_5),K_UE)), KEMkey(Encaps(pk(SK_MNO),rUE 2))),hmac(senckey((fAKID((fATID(SUPI,K),ID MNO 5)),ID AF 5,hmac((user id,ID AF 5),K UE)),KEMkey(Encaps(pk(SK_MNO), rUE_2))),KEMkey(Encaps(pk(SK_MNO),rUE_2))),ID_AF_5) {60} event MNObegin(senckey((fAKID((fATID(SUPI, K),ID MNO 5)),ID AF 5,hmac((user id,ID AF 5),K UE)), KEMkey(Encaps(pk(SK MNO),rUE 2)))) {61} event MNOrecReqAF(senckey((fAKID((fATID(SUPI, K),ID MNO 5)),ID AF 5,hmac((user id,ID AF 5),K UE)), KEMkey(Encaps(pk(SK MNO),rUE 2))),hmac(senckey((fAKID((fATID(SUPI,K),ID MNO 5)),ID AF 5,hmac((user id,ID AF 5),K UE)),KEMkey(Encaps(pk(SK MNO), rUE 2))),KEMkey(Encaps(pk(SK MNO),rUE 2))),ID AF 5) {62} event MNOhasN(senckey((fAKID((fATID(SUPI,K), ID_MNO_5)),ID_AF_5,hmac((user id,ID AF 5),K UE)), KEMkey(Encaps(pk(SK_MNO),rUE_2)))) {64} event MNOhasKshMNO(DecapsKey(SK_MNO,KEMCipher(Encaps(pk(SK_MNO),rUE_2)))) {67} event trMAC(hmac(senckey((fAKID((fATID(SUPI, K),ID MNO 5)),ID AF 5,hmac((user id,ID AF 5),K UE)), KEMkey(Encaps(pk(SK_MNO),rUE_2))),DecapsKey(SK_MNO, KEMCipher(Encaps(pk(SK MNO),rUE 2))))) {69} event MNOgetAKID(fAKID((fATID(SUPI,K),ID_MNO_5))) {70} event MNOgetIDAF(ID AF 5) {71} event MNOgetT(hmac((user_id,ID_AF_5),K_UE)) {73} event trIDAF(ID_AF_5) {87} get database(fAKID((fATID(SUPI,K),ID_MNO_5)), SUPI,fKAKMA(SUPI,K)) {75} event yesKAKMA(fKAKMA(SUPI,K)) {77} event MNOhasKAF(fKAF(ID_AF_5,fKAKMA(SUPI,K))) {80} event MNOhasKpAF(KDF2(DecapsKey(SK MNO,KEMCipher(Encaps(pk(SK_MNO),rUE_2))),fKAF(ID_AF_5,fKAKMA({82} event MNOhasHID(hmac((hmac((user id,ID AF 5), K_UE),SUPI,ID_AF_5),K_MNO)) {83} event MNOsendResAF(hmac((hmac((user id,ID AF 5), K UE), SUPI, ID AF 5), K MNO), fexp(fKAF(ID AF 5, fKAKMA(SUPI,K))),KDF2(DecapsKey(SK_MNO,KEMCipher(Encaps(pk(SK MNO),rUE 2))),fKAF(ID AF 5,fKAKMA(SUPI,K)))) {84} event MNOendN(senckey((fAKID((fATID(SUPI,K), ID_MNO_5)),ID_AF_5,hmac((user_id,ID_AF_5),K_UE)), KEMkey(Encaps(pk(SK_MNO),rUE_2)))) {85} event MNOendKpAF(fKAF(ID_AF_5,fKAKMA(SUPI, K)))

hmac((user_id,ID_AF_5),K_UE)),KEMkey(Encaps(pk(<u>SK</u> MNO),rUE_1))) \sim M_2 = KEMCipher(Encaps(pk(SK_MNO),rUE_1))

 \sim M 3 = hmac(senckey((fAKID((fATID(SUPI,K),ID MNO 5)), ID AF 5,hmac((user id,ID AF 5),K UE)),KEMkey(Encaps(pk(SK_MNO),rUE_1))),KEMkey(Encaps(pk(SK_MNO),rUE_1)))

 \sim M 5 = senckey((fAKID((fATID(SUPI,K),ID MNO 5)),ID AF 5, hmac((user id,ID AF_5),K_UE)),KEMkey(Encaps(pk(SK_MNO),rUE_2)))

 \sim M_6 = KEMCipher(Encaps(pk(SK_MNO),rUE_2)) \sim M_7 = hmac(senckey((fAKID((fATID(SUPI,K),ID_MNO_5)), ID AF_5,hmac((user_id,ID_AF_5),K_UE)),KEMkey(Encaps(pk(SK_MNO),rUE_2))),KEMkey(Encaps(pk(SK_MNO),rUE_2)))

 \sim X 1 = (senckey((fAKID((fATID(SUPI,K),ID MNO 5)),ID AF 5, hmac((user id,ID AF 5),K UE)),KEMkey(Encaps(pk(SK_MNO),rUE_2))),KEMCipher(Encaps(pk(SK_MNO),rUE_2)), hmac(senckey((fAKID((fATID(SUPI,K),ID MNO 5)), ID AF 5,hmac((user id,ID AF 5),K UE)),KEMkey(Encaps(pk(SK_MNO),rUE_2))),KEMkey(Encaps(pk(SK_MNO),rUE_2))),

A trace has been found.