```
send-once__realizes  THM

⊢  ∀T,A:Type, a:Id, f:(A→T), tg:Id, l:IdLnk, x:Id.
|  ¬"done" = x
|  ⇒
|  A
|  ⇒
|  T
|  ⇒
|  λloc.⊕(send-once(loc;T;A;a;f;tg;l;x))
|  realizes es.(vartype(source(l);x) ⊆r A)
|              & (∀e:E. kind(e) = rcv(l; tg) ⇒ (valtype(e) ⊆r T))
|              & (∃e:E.
|                 kind(e) = rcv(l; tg)
|                 & val(e) = f((x when sender(e)))
|                   & kind(sender(e)) = locl(a)
|                   & (∀e':E.
|                      kind(e') = rcv(l; tg)
|                      ⇒
|                      kind(sender(e')) = locl(a) ⇒ e' = e))
| by RealizerSetup THEN InstRealizerLemma `once` [a;source(l)]
|
1. T : Type
2. A : Type
3. a : Id
4. f : A→T
5. tg : Id
6. l : IdLnk
7. x : Id
8. ¬"done" = x
9. A
10. T
11. (λloc.⊕(send-once(loc;T;A;a;f;tg;l;x))) ∈ Dsys
12. D' : Dsys
13. λloc.⊕(send-once(loc;T;A;a;f;tg;l;x)) ⊆ D'
14. w : World
15. p : FairFifo
16. PossibleWorld(D';w)
17. ∃e@source(l).kind(e) = locl(a)
|   & ∀e@source(l).∀e'@source(l).kind(e) = locl(a)
|                                 ⇒
|     kind(e') = locl(a) ⇒ e = e'
⊢  (vartype(source(l);x) ⊆r A)
|  & (∀e:E. kind(e) = rcv(l; tg) ⇒ (valtype(e) ⊆r T))
|  & (∃e:E.
|     kind(e) = rcv(l; tg)
|     & val(e) = f((x when sender(e)))
|       & kind(sender(e)) = locl(a)
|       & (∀e':E.
|          kind(e') = rcv(l; tg)
|          ⇒
|          kind(sender(e')) = locl(a) ⇒ e' = e))
| by USendRule1 l locl(a) x tg A Unit T (λa,b. f(a)) THENA MaAuto
|
1. T : Type
```

```
2. A : Type
3. a : Id
4. f : A⟶T
5. tg : Id
6. l : IdLnk
7. x : Id
8. ¬"done" = x
9. A
10. T
11. (λloc.⊕(send-once(loc;T;A;a;f;tg;l;x))) ∈ Dsys
12. D' : Dsys
13. λloc.⊕(send-once(loc;T;A;a;f;tg;l;x)) ⊆ D'
14. w : World
15. p : FairFifo
16. PossibleWorld(D';w)
17. ∃e@source(l).kind(e) = locl(a)
18. ∀e@source(l).∀e'@source(l).kind(e) = locl(a)
|                                ⇒
|   kind(e') = locl(a) ⇒ e = e'
19. @source(l): ma-single-sends1(A;
|                                Unit;
|                                T;
|                                x;
|                                locl(a);
|                                l;
|                                tg;
|                                (λa,b. [(f(a))]))
|   ∈ Dsys
20. vartype(source(l);x) ⊆r A
21. ∀e:E.
|   loc(e) = source(l) ⇒ kind(e) = locl(a) ⇒ (valtype(e) ⊆r Unit)
22. ∀e:E. kind(e) = rcv(l; tg) ⇒ (valtype(e) ⊆r T)
23. ∀e:E.
|   loc(e) = source(l)
|   ⇒
|   kind(e) = locl(a)
|   ⇒
|   (∃e':E.
|    kind(e') = rcv(l; tg)
|    & sender(e') = e
|      & (∀e'':E.
|         kind(e'') = rcv(l; tg) ⇒ sender(e'') = e ⇒ e'' = e')
|      & val(e') = f((x when e)))
⊢  (vartype(source(l);x) ⊆r A)
|  & (∀e:E. kind(e) = rcv(l; tg) ⇒ (valtype(e) ⊆r T))
|  & (∃e:E.
|     kind(e) = rcv(l; tg)
|     & val(e) = f((x when sender(e)))
|       & kind(sender(e)) = locl(a)
|       & (∀e':E.
|          kind(e') = rcv(l; tg)
|          ⇒
|          kind(sender(e')) = locl(a) ⇒ e' = e))
| by BetterSplitAndConcl THEN Try Trivial THEN Thin -1
|    THEN
```

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|    All (Unfolds [‘alle-at‘;‘existse-at‘])
|    THEN
|    ExRepD
|    THEN
|    AllHyps
|    (λh.
|     InstHyp [e] h THENA Complete Auto THEN ParallelOp -1 THEN ExRepD
|     THEN
|     MaAuto)
|
|\
| 1. T : Type
| 2. A : Type
| 3. a : Id
| 4. f : A→T
| 5. tg : Id
| 6. l : IdLnk
| 7. x : Id
| 8. ¬"done" = x
| 9. A
| 10. T
| 11. (λloc.⊕(send-once(loc;T;A;a;f;tg;l;x))) ∈ Dsys
| 12. D’ : Dsys
| 13. λloc.⊕(send-once(loc;T;A;a;f;tg;l;x)) ⊆ D’
| 14. w : World
| 15. p : FairFifo
| 16. PossibleWorld(D’;w)
| 17. e : E
| 18. loc(e) = source(l)
| 19. kind(e) = locl(a)
| 20. ∀e:E.
| |   loc(e) = source(l)
| |   ⇒
| |   (∀e’:E.
| |    loc(e’) = source(l)
| |    ⇒
| |    kind(e) = locl(a) ⇒ kind(e’) = locl(a) ⇒ e = e’)
| 21. @source(l): ma-single-sends1(A;
| |                                Unit;
| |                                T;
| |                                x;
| |                                locl(a);
| |                                l;
| |                                tg;
| |                                (λa,b. [(f(a))]))
| |   ∈ Dsys
| 22. vartype(source(l);x) ⊆r A
| 23. ∀e:E.
| |   loc(e) = source(l) ⇒ kind(e) = locl(a) ⇒ (valtype(e) ⊆r Unit)
| 24. ∀e:E. kind(e) = rcv(l; tg) ⇒ (valtype(e) ⊆r T)
| 25. ∀e:E.
| |   loc(e) = source(l)
| |   ⇒
| |   kind(e) = locl(a)
| |   ⇒
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| |   (∃e':E.
| |    kind(e') = rcv(l; tg)
| |    & sender(e') = e
| |      & (∀e'':E.
| |         kind(e'') = rcv(l; tg) ⇒ sender(e'') = e ⇒ e'' = e')
| |      & val(e') = f((x when e)))
| 26. e' : E
| 27. kind(e') = rcv(l; tg)
| 28. sender(e') = e
| 29. ∀e'':E. kind(e'') = rcv(l; tg) ⇒ sender(e'') = e ⇒ e'' = e'
| 30. val(e') = f((x when e))
| ⊢  val(e') = f((x when sender(e')))  by StrongHypSubst -3 0
| |
| .....subterm .....
| 1. T : Type
| 2. A : Type
| 3. a : Id
| 4. f : A→T
| 5. tg : Id
| 6. l : IdLnk
| 7. x : Id
| 8. ¬"done" = x
| 9. A
| 10. T
| 11. (λloc.⊕(send-once(loc;T;A;a;f;tg;l;x))) ∈ Dsys
| 12. D' : Dsys
| 13. λloc.⊕(send-once(loc;T;A;a;f;tg;l;x)) ⊆ D'
| 14. w : World
| 15. p : FairFifo
| 16. PossibleWorld(D';w)
| 17. e : E
| 18. loc(e) = source(l)
| 19. kind(e) = locl(a)
| 20. ∀e:E.
| |   loc(e) = source(l)
| |   ⇒
| |   (∀e':E.
| |    loc(e') = source(l)
| |    ⇒
| |    kind(e) = locl(a) ⇒ kind(e') = locl(a) ⇒ e = e')
| 21. @source(l): ma-single-sends1(A;
| |                                 Unit;
| |                                 T;
| |                                 x;
| |                                 locl(a);
| |                                 l;
| |                                 tg;
| |                                 (λa,b. [(f(a))]))
| |   ∈ Dsys
| 22. vartype(source(l);x) ⊆r A
| 23. ∀e:E.
| |   loc(e) = source(l) ⇒ kind(e) = locl(a) ⇒ (valtype(e) ⊆r Unit)
| 24. ∀e:E. kind(e) = rcv(l; tg) ⇒ (valtype(e) ⊆r T)
| 25. ∀e:E.
| |   loc(e) = source(l)
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| |   ⇒
| |   kind(e) = locl(a)
| |   ⇒
| |   (∃e':E.
| |    kind(e') = rcv(l; tg)
| |    & sender(e') = e
| |      & (∀e'':E.
| |         kind(e'') = rcv(l; tg) ⇒ sender(e'') = e ⇒ e'' = e')
| |      & val(e') = f((x when e)))
| 26. e' : E
| 27. kind(e') = rcv(l; tg)
| 28. sender(e') = e
| 29. ∀e'':E. kind(e'') = rcv(l; tg) ⇒ sender(e'') = e ⇒ e'' = e'
| 30. val(e') = f((x when e))
| 31. z : E
| 32. z = e
| ⊢  (x when z) ∈ A  by DoSubsume THEN HypSubst -1 0
| |
| 1. T : Type
| 2. A : Type
| 3. a : Id
| 4. f : A→T
| 5. tg : Id
| 6. l : IdLnk
| 7. x : Id
| 8. ¬"done" = x
| 9. A
| 10. T
| 11. (λloc.⊕(send-once(loc;T;A;a;f;tg;l;x))) ∈ Dsys
| 12. D' : Dsys
| 13. λloc.⊕(send-once(loc;T;A;a;f;tg;l;x)) ⊆ D'
| 14. w : World
| 15. p : FairFifo
| 16. PossibleWorld(D';w)
| 17. e : E
| 18. loc(e) = source(l)
| 19. kind(e) = locl(a)
| 20. ∀e:E.
|     loc(e) = source(l)
|     ⇒
|     (∀e':E.
|      loc(e') = source(l)
|      ⇒
|      kind(e) = locl(a) ⇒ kind(e') = locl(a) ⇒ e = e')
| 21. @source(l): ma-single-sends1(A;
|                                  Unit;
|                                  T;
|                                  x;
|                                  locl(a);
|                                  l;
|                                  tg;
|                                  (λa,b. [(f(a))]))
|     ∈ Dsys
| 22. vartype(source(l);x) ⊆r A
| 23. ∀e:E.
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|     loc(e) = source(l) ⇒ kind(e) = locl(a) ⇒ (valtype(e) ⊆r Unit)
| 24. ∀e:E. kind(e) = rcv(l; tg) ⇒ (valtype(e) ⊆r T)
| 25. ∀e:E.
|     loc(e) = source(l)
|     ⇒
|     kind(e) = locl(a)
|     ⇒
|     (∃e':E.
|      kind(e') = rcv(l; tg)
|      & sender(e') = e
|        & (∀e'':E.
|           kind(e'') = rcv(l; tg) ⇒ sender(e'') = e ⇒ e'' = e')
|        & val(e') = f((x when e)))
| 26. e' : E
| 27. kind(e') = rcv(l; tg)
| 28. sender(e') = e
| 29. ∀e'':E. kind(e'') = rcv(l; tg) ⇒ sender(e'') = e ⇒ e'' = e'
| 30. val(e') = f((x when e))
| 31. z : E
| 32. z = e
| ⊢  vartype(loc(e);x) ⊆r A
|   by AllHyps (λh.NthHypEq h THEN Complete (Repeat Analyze))
|
.\
. 1. T : Type
. 2. A : Type
. 3. a : Id
. 4. f : A→T
. 5. tg : Id
. 6. l : IdLnk
. 7. x : Id
. 8. ¬"done" = x
. 9. A
. 10. T
. 11. (λloc.⊕(send-once(loc;T;A;a;f;tg;l;x))) ∈ Dsys
. 12. D' : Dsys
. 13. λloc.⊕(send-once(loc;T;A;a;f;tg;l;x)) ⊆ D'
. 14. w : World
. 15. p : FairFifo
. 16. PossibleWorld(D';w)
. 17. e : E
. 18. loc(e) = source(l)
. 19. kind(e) = locl(a)
. 20. ∀e:E.
. |   loc(e) = source(l)
. |   ⇒
. |   (∀e':E.
. |    loc(e') = source(l)
. |    ⇒
. |    kind(e) = locl(a) ⇒ kind(e') = locl(a) ⇒ e = e')
. 21. @source(l): ma-single-sends1(A;
. |                                Unit;
. |                                T;
. |                                x;
. |                                locl(a);
```

```
. |                                l;
. |                                tg;
. |                                (λa,b. [(f(a))]))
. |   ∈ Dsys
. 22. vartype(source(l);x) ⊆r A
. 23. ∀e:E.
. |   loc(e) = source(l) ⇒ kind(e) = locl(a) ⇒ (valtype(e) ⊆r Unit)
. 24. ∀e:E. kind(e) = rcv(l; tg) ⇒ (valtype(e) ⊆r T)
. 25. ∀e:E.
. |   loc(e) = source(l)
. |   ⇒
. |   kind(e) = locl(a)
. |   ⇒
. |   (∃e':E.
. |    kind(e') = rcv(l; tg)
. |    & sender(e') = e
. |      & (∀e'':E.
. |         kind(e'') = rcv(l; tg) ⇒ sender(e'') = e ⇒ e'' = e')
. |      & val(e') = f((x when e)))
. 26. e' : E
. 27. kind(e') = rcv(l; tg)
. 28. sender(e') = e
. 29. ∀e'':E. kind(e'') = rcv(l; tg) ⇒ sender(e'') = e ⇒ e'' = e'
. 30. val(e') = f((x when e))
. 31. e'@0 : E
. 32. kind(e'@0) = rcv(l; tg)
. 33. kind(sender(e'@0)) = locl(a)
. ⊢  e'@0 = e'  by BackThruSomeHyp
. |
. 1. T : Type
. 2. A : Type
. 3. a : Id
. 4. f : A→T
. 5. tg : Id
. 6. l : IdLnk
. 7. x : Id
. 8. ¬"done" = x
. 9. A
. 10. T
. 11. (λloc.⊕(send-once(loc;T;A;a;f;tg;l;x))) ∈ Dsys
. 12. D' : Dsys
. 13. λloc.⊕(send-once(loc;T;A;a;f;tg;l;x)) ⊆ D'
. 14. w : World
. 15. p : FairFifo
. 16. PossibleWorld(D';w)
. 17. e : E
. 18. loc(e) = source(l)
. 19. kind(e) = locl(a)
. 20. ∀e:E.
.     loc(e) = source(l)
.     ⇒
.     (∀e':E.
.      loc(e') = source(l)
.      ⇒
.      kind(e) = locl(a) ⇒ kind(e') = locl(a) ⇒ e = e')
```

```
. 21. @source(l): ma-single-sends1(A;
.                                  Unit;
.                                  T;
.                                  x;
.                                  locl(a);
.                                  l;
.                                  tg;
.                                  (λa,b. [(f(a))]))
.     ∈ Dsys
. 22. vartype(source(l);x) ⊆r A
. 23. ∀e:E.
.     loc(e) = source(l) ⇒ kind(e) = locl(a) ⇒ (valtype(e) ⊆r Unit)
. 24. ∀e:E. kind(e) = rcv(l; tg) ⇒ (valtype(e) ⊆r T)
. 25. ∀e:E.
.     loc(e) = source(l)
.     ⇒
.     kind(e) = locl(a)

.     ⇒
.     (∃e':E.
.      kind(e') = rcv(l; tg)
.      & sender(e') = e
.        & (∀e'':E.
.           kind(e'') = rcv(l; tg) ⇒ sender(e'') = e ⇒ e'' = e')
.        & val(e') = f((x when e)))
. 26. e' : E
. 27. kind(e') = rcv(l; tg)
. 28. sender(e') = e
. 29. ∀e'':E. kind(e'') = rcv(l; tg) ⇒ sender(e'') = e ⇒ e'' = e'
. 30. val(e') = f((x when e))
. 31. e'@0 : E
. 32. kind(e'@0) = rcv(l; tg)
. 33. kind(sender(e'@0)) = locl(a)
. ⊢  sender(e'@0) = e
.   by AllHyps (λh.BackThru h THEN Complete MaAuto)
END
```